The impact of neighbourhood and school environments on ethnic differences in body size in adolescence

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Abstract

Background: Ethnicity is associated with childhood obesity, with Black African origin girls in particular being more vulnerable to overweight and obesity than their White European peers. In the UK, ethnic minorities often live and attend school in poor urban areas which may influence their opportunity for physical activity and a healthy diet.

Aim: To examine neighbourhood and school effects on ethnic differences in Body Mass Index (BMI) and waist circumference trends in adolescence.

Methods: Multilevel analysis of longitudinal data on BMI and waist circumference [standard deviation scores (SDS)] from 3401 adolescents in the Determinants of Adolescent Social well-being and Health (DASH) Study (870 White UK, 778 Black Caribbean, 504 Nigerian/Ghanaian, 386 Other African, 418 Indian, and 445 Pakistani/Bangladeshi). Forty-nine London schools participated in the study and the same pupils were surveyed at 11-13yrs and 14-16yrs. Neighbourhood measures included deprivation, crime, and ethnic density; school measures included ethnic density, school socioeconomic status (SES) (academic performance, free school meals, unauthorised absence) and ethos. Individual and family characteristics were also examined (including dietary and physical activity measures, family SES, and parental overweight).

Results: Between 11 and 16yrs ethnic differences in BMI emerged in boys and persisted in girls; compared to their White UK peers Black Caribbean and Nigerian/Ghanaian boys and girls, and Other African girls, had a greater mean BMI SDS. These patterns were not observed for waist circumference, signalling ethnic differences in fat distribution or body composition. The DASH pupils overall had large waists compared to the 1990 Growth Reference population. The ethnic minority pupils, with the exception of the Indians, were more likely to live in more deprived, higher crime, less green areas than their White UK peers. However the ethnic minority pupils often attended better performing schools than the White UK pupils. The overall variance in body size at neighbourhood level or school level was small (<4%), and area or school context measures had little or no effect on ethnic differences in body size. Individual characteristics (such as age, pubertal status, and skipping breakfast) and maternal overweight were strong correlates of body size but did not explain the ethnic differences observed.

Conclusions: There were significant ethnic differences in BMI in adolescence, emergent in late adolescence for boys. Neighbourhood and school contexts did not explain the ethnic differences in BMI age trends.

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Author's declaration

I declare that, except where acknowledged, the work presented within this thesis was undertaken by myself.

Alison Teyhan

1 Introduction

This thesis examines the impact of neighbourhood and school contexts on ethnic differences in body size in adolescence in the UK. Excess body fat is a risk factor for cardiovascular disease (CVD), and it is well established that there are ethnic differences in the prevalence of both obesity and CVD. However, less is known about the causes of these ethnic inequalities or when in the life course they begin to emerge. It is increasingly recognised that contextual factors may play an important role, and it is these factors which are the focus of this thesis. The data used are longitudinal, from a school-based study that contained residential postcode data; this allowed ethnic-specific age trends in body size to be examined and the impact of both neighbourhood and school contexts to be explored.

This introduction chapter is structured into four main parts. The first part sets the background of the thesis. It starts by describing the ethnic minority groups in the UK and their migration histories. It then defines obesity and highlights its public health importance. Ethnic differences in overweight and obesity in the UK are then discussed. An overview of the determinants of obesity is then given, with a focus on potential explanations for ethnic differences in body size. This background section concludes by stressing the potential importance of neighbourhood environments. The second part then gives an overview of how neighbourhoods could have an effect on health. The third part then examines the evidence to date for neighbourhood and school effects on diet, physical activity and body size in adolescents. Finally, section four details the aims and objectives of this thesis and gives an overview of the structure of the thesis.

1.1 Background

1.1.1 Ethnic minority groups in the UK

Ethnicity incorporates a large social dimension, unlike the purely biological concept of race which is based on physical features and now viewed as an ‘artificial construct’ with no scientific validity (Bhopal, 2004, Nazroo, 1998). People of the same ethnicity are perceived to share characteristics including cultural traditions, language, religion, and geographical and ancestral origins (Bhopal, 2004). Over 4.6 million people in the UK belonged to a non-White ethnic minority group (7.9% of the UK population) in the 2001 Census (ONS, 2011). The largest non-White ethnic groups were: Indian (23% of the non-White ethnic minorities), Pakistani (16%), Bangladeshi (6%), Black Caribbean (12%), Black African (11%), and Mixed (15%, of whom a third were mixed White and Black Caribbean). There was a 53% increase in the number of non-White ethnic minorities in Great Britain between 1991 and 2001. London is the UK's most ethnically diverse city; in 2001 29% of its population was non-White and 45% of all non-White ethnic minorities in the UK lived there. Some groups were particularly concentrated in London; 78% of Black Africans, 61% of Black Caribbeans and 54% of Bangladeshis lived there. In contrast, only 19% of Pakistanis in the UK lived in London.

Reasons for migration to the UK differ by ethnic group. Due to labour shortages after World War II the British government encouraged migration from its former colonies and this resulted in large numbers of migrants from the Caribbean (mainly Jamaica) and South Asia to the UK in the 1950s and 60s. Migration from these Commonwealth countries was effectively ended by the 1971 Immigration Act. South Asians (mainly Gujarati Indians) also migrated to the UK from Uganda in the early 1970s. Many Black Caribbeans and South Asians in the UK are UK-born. Migration of Black Africans to the UK generally started later than that of South Asians and Caribbeans and numbers were small until the 1990s. Black Africans in the UK are a diverse group from over 40 nations and migration patterns differ by country of origin (Mitton and Aspinall, 2010). Nigerians and Ghanaians are the largest and most established Black African communities in the UK; migrants from these former British colonies came to the UK from the 1950s and 1960s onwards for employment and education. From the early 1990s to early 2000s asylum was a major reason for African migration to the UK. By the late 2000s there was more African migration for employment and education than for asylum. Many Black Africans in the UK are therefore relatively recent migrants and the majority of UK-born Black Africans are under 16yrs (Mitton and Aspinall, 2010).

1.1.2 Overweight and obesity

Overweight and obesity are serious and growing global health problems. In the past 30 years worldwide obesity rates have doubled (WHO, 2011). During this time childhood obesity has increased substantially in almost all industrialised countries and in several lower-income countries; from the 1970s to the late 1990s rates of childhood overweight and obesity more than doubled in many countries, including the UK (Wang and Lobstein, 2006). Obesity rates in the UK are currently among the highest in the world; in the Health Survey for England 2009 almost a quarter of adults were obese and 66% of men and 57% of women were overweight or obese. Rates were also high in children; 16% of children aged 2-15yrs were obese and 31% of boys and 28% of girls were overweight or obese (National Centre for Social Research, 2010).

Overweight and obesity are major risk factors for many leading causes of death including type 2 diabetes, cardiovascular disease (CVD), and some cancers (Bianchini et al., 2002, Felber and Golay, 2002, Hubert et al., 1983). Childhood obesity is of major concern due to its negative impact on health in both the long and short term (Reilly and Wilson, 2006). Short term consequences include pulmonary, orthopaedic, and psychological problems plus early markers of cardiovascular disease and insulin resistance (Daniels, 2006, Gahagan, 2004, Reilly et al., 2003). In the longer term, childhood obesity is associated with CVD and other morbidities, plus overall mortality, in adulthood (Baker et al., 2007, Dietz, 1998, Reilly et al., 2003). It has been suggested that the increasing prevalence and severity of childhood obesity could result in today's children having a shorter lifespan than their parents (Daniels, 2006). In addition to serious health consequences, obesity and its comorbidities have substantial financial implications for health care systems (Allender and Rayner, 2007, Finkelstein et al., 2005, Wang and Dietz, 2002).

Overweight and obesity can be defined in a variety of ways (Scarborough et al., 2010). Body mass index (BMI) [weight (kg)/height (m^2)] is the most commonly used weight independent of height measure of body size. Cut-offs designated by the WHO are commonly used to define overweight (25 to <30) and obesity (≥30) in adults and corresponding age and sex specific cut-offs have been derived for children (Cole et al., 2000). The adult cut-offs are arbitrary and were chosen for pragmatic reasons; crossing from one weight category to another does not substantially increase disease risk as the relationship between BMI and diabetes, hypertension, and CHD is linear from a BMI of 20 upwards (James et al., 2001, Willett et al., 1999). An important limitation of BMI is that it does not distinguish between lean and fat mass, and it does not measure the distribution of body fat.

Central adiposity (also known as visceral or intra-abdominal fat) is strongly related to cardiovascular and metabolic disease, with some but not all studies finding the relationship to be stronger than that observed for BMI (Canoy et al., 2007, Hamdy et al., 2006, Huxley et al., 2010). The adverse effect of central adiposity on lipid profiles and insulin levels has also been observed in children and adolescents (Asayama et al., 1998, Freedman et al., 1999, McCarthy et al., 2006, Yan et al., 2006). Waist circumference and waist-hip-ratio

(WHR) are indirect measures of central adiposity (Hamdy et al., 2006). Waist circumference measures visceral organs plus abdominal (both subcutaneous and intra-abdominal) fat. Hip circumference reflects muscle mass and skeletal frame in addition to fat mass (International Agency for Research on Cancer, 2002). In recent decades in the UK waist circumference has increased more rapidly than BMI in young people (11-16yrs), particularly in girls, which suggests that BMI underestimates obesity prevalence in adolescents as it cannot detect the shift in body composition that has occurred (from less fat-free mass to more fat mass for a given BMI) (McCarthy et al., 2003). However a recent UK study concluded that waist circumference had no benefit over BMI in determining high fat mass in children when compared to results from dual energy x-ray absorptiometry (Reilly et al., 2010).

Body composition and fat distribution differ by ethnicity. Compared to Whites, at any given BMI Black adults and children tend to have less body fat and less central adiposity than White people (Conway et al., 1995, Freedman et al., 2008, Shaw et al., 2007, Sisson et al., 2009, Wagner and Heyward, 2000). In contrast, at a given BMI South Asian children and adults generally have a higher percentage of body fat and more central adiposity than Whites (Banerji et al., 1999, Deurenberg et al., 2002, Shaw et al., 2007). As fat distribution differs by ethnicity it is useful to use more than one measure of body size when examining ethnic differences in obesity (Scarborough et al., 2010). Furthermore as the relationship between percentage body fat and BMI is ethnic specific, it has been argued that universal BMI cut-off points are not appropriate for comparing obesity prevalence between ethnic groups (Deurenberg et al., 2002).

Weight gain results from an imbalance between energy intake and energy expenditure. The intake of energy is determined solely by diet; energy expenditure has four components (resting metabolic rate; thermic effect of food; posture and spontaneous activity; and voluntary physical activity), of which physical activity is the only one which is modifiable (International Agency for Research on Cancer, 2002, page 6). The body stores excess energy as fat, therefore overweight and obesity are a consequence of an individual chronically consuming more calories than they expend (Spiegelman and Flier, 2001).

Excess body fat can begin at a young age; in the UK Millennium Cohort Study 23% of 3yr olds were already overweight or obese (Hawkins et al., 2009). Childhood obesity is of concern because of its effects on health in the short term and because it can track through to adulthood. BMI in childhood is associated with BMI in adulthood, and overweight and obese children are at increased risk of becoming overweight and obese adults (Freedman et al., 2005, Guo and Chumlea, 1999, Singh et al., 2008). A US-based study found ethnic differences in the tracking of body size; a higher proportion of overweight Black children became obese adults (girls 84%, boys 82%) than overweight White children (girls 65%, boys 71%). However thin White boys were more likely to become overweight adults than thin Black boys (Freedman et al., 2005). In addition to body size measures, dietary behaviours track from childhood into adulthood (Mikkila et al., 2004) and physical activity levels reduce with age in children, with the reduction being more marked in girls (Goran et al., 1999). Given that obesity is difficult to treat, childhood and adolescence are key periods for interventions to set individuals on a healthier trajectory.

1.1.3 Ethnic differences in obesity in the UK

To date no longitudinal study in the UK has examined ethnic specific trends in body size from childhood to adolescence, or adolescence to adulthood. Therefore information on ethnic differences in body size at different stages in the lifecourse has to be gleaned from various cross-sectional studies or from a small number of longitudinal studies which have relatively short follow-up periods. This section will first give a brief overview of what data are available for children, adolescents, and adults, and then describe ethnic differences in body size at each age.

A recent systematic review on ethnic inequalities in obesity in children and adults in the UK between 1980 and 2010 identified 14 peer-reviewed studies on children (2 longitudinal, 12 cross sectional) and 15 on adults (all cross sectional) (El-Sayed et al., 2011). Several weaknesses in the available data are highlighted in this review. The lack of longitudinal data hinders the analysis of ethnic differences in age trends, or investigation into the causal mechanisms of ethnic differences. A further limitation is that many of the studies aggregate ethnic groups with distinct social and cultural backgrounds into one broad category. Many studies were localised to one geographical area; given that the prevalence of obesity differs across the UK, and characteristics of the ethnic minority groups may differ depending on location, this limits the generalisability of study findings. An additional limitation is that the majority of studies used only one measure of body size; as body composition and fat distribution differ by ethnicity, studies which use only weight for height measures (such as BMI or obesity categories based on BMI) may systematically over-estimate obesity in Black Africans and Caribbeans and underestimate it in South

Asians. As definitions of body size and weight categories differed between studies a meta-analyses could not be performed.

Few studies included young children. Only one study focused on pre-school children and used data from the Millennium Cohort Study (MCS), but despite a large sample size there were relatively small numbers of ethnic minority children (87% of the 13,000 sample were White); this study disaggregated the South Asians (into Indian, Pakistani, and Bangladeshi) but all of the Black children were in one category (Hawkins et al., 2009). A later piece of work, published since the review, examined ethnic differences in body size from birth to 5yrs in the MCS and disaggregated both the Black and South Asian groups (Lenguerrand and Harding, 2010). Several studies included older children. One of the most recent, which took place in 2004-2006, was the cross-sectional Child Heart And Health Study (CHASE) which included almost 4800 children aged 9-10yrs in London, Birmingham, and Leicester (Whincup et al., 2010). This study did not disaggregate either the South Asian or Black African-Caribbean groups.

With regards to adolescents, in the past decade three cohort studies of adolescent health have examined ethnic differences in body size in young people: DASH (Harding et al., 2007), HABITS (Wardle et al., 2003), and RELACHS (Taylor et al., 2005) (Table 1.1). (This thesis uses data from the DASH study and more details on it are provided in the Methods chapter). All three of these studies had a longitudinal design, however to date they only have measures spanning 2 to 5yrs and RELACHS has only published cross-sectional body size data. These studies are entirely London based although they differ in the boroughs they include and hence the ethnicity of their samples. RELACHS, based in East London, has a large number of Bangladeshis. DASH, which sampled from a wider range of London locations, has good representation of the main ethnic groups, with particularly large numbers of Black Caribbeans and Black Africans relative to the other studies. HABITS used a simplified ethnicity variable; Black Caribbeans and Black Africans are combined into one category, as are the South Asian groups.

Several of the adult studies used data from the Health Surveys for England (HSE) (Diaz et al., 2007, Moon et al., 2007, Rennie and Jebb, 2005, Wardle et al., 2002). The HSE are nationally representative annual surveys that include measures of body size. One study of young people (2-20yrs) also used the HSE (Saxena et al., 2004). These studies have the advantage of a large sample size and national data but two used aggregated ethnicity categories (White, Black, Asian) (Moon et al., 2007, Wardle et al., 2002). The other adult studies were all located in single cities in the UK.

Table 1.1 Recent UK cohort studies of ethnic differences in body size in adolescents

Name of Study, Design, Year	Setting	Sample size, age range	Ethnic groups, how defined	Body size outcome measures
DASH (Determinants of Adolescent Social well-being and Health) Longitudinal 2002/2003 (Baseline) 2005/2006 (Follow-up)	51 schools in 10 London boroughs (covering North, South, East and West London).	6643 (baseline) 11-13yrs (baseline), 14-16yrs at follow-up.	White UK (19%), White Other (11%), Black Caribbean (14%), Nigerian/Ghanaian (9%), Other African (7%), Indian (7%), Pakistani/Bangladeshi (10%), Mixed (13%), Other (10%). Self-reported own and parental ethnicity, and own, parental and grandparental country of birth.	BMI, Overweight/Obesity, Waist circumference
HABITS (Health And Behaviour In Teenagers Study) Longitudinal 1999 (Baseline) Annual surveys until 2003	36 schools in 13 South London boroughs.	4320 (baseline) 11-12yrs (baseline), 15-16yrs at final survey.	White (57%), Black (17%), Asian (8%), Mixed/Other (10%), Not Stated (9%). Self-reported own ethnicity.	BMI, Overweight/Obesity, Waist circumference
RELACHS (Research in East London Adolescents Community Health Survey) Longitudinal 2001 (Baseline) 2003 (Follow-up)	36 schools in 3 boroughs in East London.	2482 11-14yrs (baseline)	White British (21%), Bangladeshi (25%), Indian (9%), Pakistani (7%) Black African (10%), Black Caribbean (6%). Self-reported own ethnicity, country of birth and languages spoken.	BMI, Overweight, Obesity

In light of these data limitations, the evidence to date for ethnic differences in overweight and obesity in the UK will now be considered. A consistent finding was that Black African and Caribbean women were more likely to be overweight and obese than their White peers (El-Sayed et al., 2011). For example, in a South London-based study 68% of African women had a BMI >27 and 40% had a BMI>30 (compared to 34% and 19% respectively for White women) (Cappuccio et al., 1997). Similarly, in the HSE 1999 32% of Black Caribbean women were obese compared to 21% of the women in the general population (Rennie and Jebb, 2005). In the HSE 2004 Black Caribbean and Black African women had larger waists and higher WHRs than the general population (ONS and NatCen, 2006). These ethnic differences in body size have been observed in adolescence. In

DASH Black Caribbean girls were more likely to be overweight and obese than White UK girls at 11-13yrs and obese at 14-16yrs, and Black African girls to be overweight at 11-13yrs (Harding et al., 2008b, Harding et al., 2010). Furthermore, there was evidence of a generational effect; second generation Black Caribbean girls were more at risk of overweight/obesity than first generation. Similarly, HABITS found Black girls to have higher levels of overweight and obesity at all ages from 11 to 16yrs (Wardle et al., 2006). In contrast to the other studies, RELACHS did not find Black Caribbean or Black African girls to be more at risk of overweight or obesity at 11-14yrs than White girls (Taylor et al., 2005). Findings for differences in central adiposity were mixed; in HABITS the Black girls had larger waist circumferences than White girls at all ages but in DASH there were no differences in waist between the Black Caribbean or Black African and the White adolescents at 11-13yrs (Harding et al., 2008b, Wardle et al., 2006). In a study which used dual x-ray absorptiometry to measure body fat, African-Caribbean girls had a significantly lower percentage body fat than their White and South Asian peers at all ages from 5 to 16yrs (adjusted for weight), but at 17-18yrs proportions were similar for the White and African-Caribbean girls (Shaw et al., 2007).

The pattern of ethnic differences between Black Caribbean/African and White boys and men was not the same as that observed for girls and women. In adulthood, Black men in the HSE 1996 were less likely to be obese than White men although this difference was not statistically significant (Wardle et al., 2002). In the HSE 2004 Black Caribbean men had lower WHRs than the general population (ONS and NatCen, 2006). In a London-based study Caribbean and West African men were more likely to have a BMI>27 than White men but differences were not significant and the proportions with a BMI>30 were similar in all three groups (Cappuccio et al., 1997). Similarly in another London based study, Afro-Caribbean men had a higher mean BMI than White men but differences were not significant, and WHR was the same in both groups (McKeigue et al., 1991). Black Caribbean and Black African adolescent boys did not have higher levels of overweight/obesity in RELACHS or HABITS (Taylor et al., 2005, Wardle et al., 2006). This was also the case in DASH at 11-13yrs, but at 14-16yrs the Black Caribbean boys were significantly more likely than the White boys to be obese (9.6% verses 4.8%) (Harding et al., 2008b, Harding et al., 2010). With regards to waist circumference, there was little ethnic difference in mean waist for boys in DASH at 11-13yrs (Harding et al., 2008b). Similarly in HABITS there was no significant difference in waist circumference but the annual rate of increase was higher for White boys than Black boys suggesting that ethnic differences could emerge (Wardle et al., 2006). As with the girls, African-Caribbean boys had significantly lower proportions of body fat than their White and Asian peers, particularly from 5 to 10yrs then 15 to 18yrs (Shaw et al., 2007).

Studies that included younger children generally did not stratify results by gender. Some studies found Black children to be more likely to be overweight that White children; in the MCS, at 3yrs of age the Black children were already significantly more likely to be overweight than the White children (30% versus 23%) (Hawkins et al., 2009). At 5yrs the Black Caribbean boys and Black African girls in this cohort had higher BMIs and larger waists than their White peers (Lenguerrand and Harding, 2010). In the HSE 1999 Black Caribbean and Black African children and adolescents (aged 2-20yrs) were almost twice as likely to be overweight and almost three times as likely to be obese as their peers in the general population (Saxena et al., 2004). However in an earlier study of 5-11yr olds, Afro-Caribbean children had similar weight-for-height measures to White children (Rona and Chinn, 1987). No significant ethnic differences in waist circumference were found between either Black African or Black Caribbean children (9-10yrs) and their White peers (Whincup et al., 2010).

Ethnic differences in body size between South Asian groups and their White UK peers will now be considered. McKeigue (1991) reported that South Asian women had significantly higher BMIs and waist circumferences than White women. In another London study South Asian woman were more likely to have a BMI>27 than White women (48% versus 34%) but the proportion with a BMI>30 was similar in both groups (around 19%) (Cappuccio et al., 1997). Similarly in a study using data from the HSE 1996 there was no significant difference in obesity levels between Asian and White women (Wardle et al., 2002). Rennie and Jebb (2005) disaggregated the South Asian group; Pakistani women were the most likely to be obese (26%) compared to 20% of Indians, and 10% of Bangladeshis. The prevalence in the general population was similar to that of the Indians (21%). A Newcastle-based study also found heterogeneity between the South Asian groups; 38% of Indian and 34% of Pakistani women were obese compared to 15% of Bangladeshi and 16% of White women (Bhopal et al., 1999). In this study the proportion of women with a WHR≥0.85 was high in each South Asian group (Indian 42%, Pakistani 60%, Bangladeshi 55%) compared to White women (17%).

Findings for adolescent girls were mixed. There were no differences in overweight or obesity levels between Whites and their Indian, Pakistani or Bangladeshi peers in RELACHS or DASH at 11-13yrs or 14-16yrs (Harding et al., 2008b, Harding et al., 2010, Taylor et al., 2005). HABITS found Asian girls to have lower overweight and obesity rates than their White and Black peers from 11 to 16yrs, with these differences being significant at some ages (Wardle et al., 2006). In the HSE 1999 Pakistani girls (2-20yrs) were significantly more likely, and Indian girls significantly less likely, to be obese than their peers in the general population (Saxena et al., 2004). In terms of central adiposity, Indian girls had larger waists than their White peers in DASH (Harding et al., 2008b) but in HABITS Asian girls had the smallest waists at all ages (Wardle et al., 2006). The South Asian girls had a higher percentage of body fat than the White girls, with the difference being greatest from 15-18yrs (Shaw et al., 2007).

For men, in the HSE surveys Bangladeshi, Pakistani and Indian men had lower BMIs and proportions overweight than the general population, and the Indians and Bangladeshis had considerably smaller waists; however the Pakistani and Bangladeshi men had higher WHRs (ONS and NatCen, 2006, Rennie and Jebb, 2005, Wardle et al., 2002). Cappuccio et al. (1997) also found South Asian men to be significantly less likely to be obese than their White peers but did not have a measure of central adiposity. Bhopal et al. (1999) included both measures; they found no significant difference between overweight rates in South Asian and White men overall, but did report heterogeneity within the South Asians. The Indians (66%) and Pakistanis (69%) were more likely to be obese than the Bangladeshis (47%) and Whites (56%). This study also measured WHR and reported that 27% of White men had a WHR≥0.85 compared to 57% of the Indians, 61% of the Pakistanis, and 63% of the Bangladeshis. Therefore even the Bangladeshis, who had a lower prevalence of overweight than the Whites, were considerably more likely to have a high WHR. Other studies also found no difference in measures of BMI/obesity between South Asian and White men but did find South Asian men to have higher central adiposity (Bose, 1995, McKeigue et al., 1991).

Findings for adolescent boys were mixed. In RELACHS, at 11-14yrs Indian boys had significantly higher rates of overweight than the White boys but the Pakistani boys had significantly lower rates of overweight, and the Bangladeshi boys had similar values to their White peers (Taylor et al., 2005). No significant difference in overweight or obesity was found between the White boys and any of the South Asian groups in DASH or

HABITS from 11 to 16yrs (Harding et al., 2008b, Harding et al., 2010, Wardle et al., 2006). In the HSE 1999 Indian and Pakistani boys (2-20yrs) were more likely to be overweight than their peers in the general population, but the Bangladeshis were significantly less likely (Saxena et al., 2004). With regards to central adiposity, there was little difference in waist circumference between any of the South Asian groups and the White boys in DASH or HABITS (Harding et al., 2008b, Wardle et al., 2006). As with the girls, South Asian boys had a higher mean percentage of body fat than their White and African-Caribbean peers, particularly at 15-16yrs, after adjustment for weight (Shaw et al., 2007).

In studies which included younger children, findings for body size differences between South Asians and Whites were also mixed. At 3yrs Indian children were significantly less likely to be overweight than their White peers but there was no difference for Pakistanis or Bangladeshis (Hawkins et al., 2009). In a study of slightly older children (5-7yrs) which stratified by gender, South Asian boys were significantly more likely to be overweight and obese, but South Asian girls significantly less likely to be overweight, than their White peers (Balakrishnan et al., 2008). In terms of central adiposity, evidence for differences in waist circumference between White and South Asian children was mixed; no difference in waist or WHR was found in 11-12yr olds in one study (Whincup et al., 2002), however a study of 9-10yr olds found White European children had significantly larger waist circumferences than the South Asian groups (Whincup et al., 2010). A study which covered a large age range (4 to 18yrs) and did not stratify by gender reported that Asians were four times more likely to be obese than Whites (Jebb et al., 2003). However in another study with a large age range (2 to 20yrs) which did stratify by gender and disaggregated the South Asian group, Bangladeshi boys were significantly less likely to be overweight and obese than their White peers whereas Indian and Pakistani boys were significantly more likely to be overweight, and Pakistani girls to be obese (Saxena et al., 2004).

Obesity is a key risk factor for cardiovascular diseases and there are ethnic differences in CVD in the UK (Scarborough et al., 2010). Black Caribbean and Black African migrants in England and Wales have low CHD mortality but high stroke mortality relative to those born in England and Wales (Marmot et al., 1984, Wild and Mckeigue, 1997). Although CVD mortality rates in England and Wales are declining, many migrant groups have experienced smaller declines over the past two decades than those born in England and

Wales (Harding et al., 2008a). These unequal rates of decline have resulted in migrants from the Caribbean losing some of their low CHD advantage. This is particularly true for Jamaica born women, who now have a CHD mortality rate significantly higher than that of England and Wales born women. Migrants from South Asia to England and Wales have elevated mortality from both CHD and stroke relative to the UK born population (Marmot et al., 1984, Wild and Mckeigue, 1997). This excess mortality has increased for some groups over the past two decades (Harding et al., 2008a).

1.1.4 Overview of determinants of obesity

The development of obesity can be considered from a lifecourse perspective; it involves both sensitive and critical periods and the accumulation of risk over time (Gillman, 2004). A 'critical period' refers to biological programming, when environmental exposures during the foetal period result in lasting changes. Foetal malnutrition can result in low birthweight, and low birthweight is associated with central obesity in later life; the association is strongest for those who are light at birth but become overweight (Oken and Gillman, 2003). A possible explanation for this association is the 'thrifty phenotype' hypothesis which proposes that foetal malnutrition results in physiological and metabolic adaptations to ensure survival in a poor nutritional environment (Hales and Barker, 2001). However if the individual is then born into an environment with adequate or over nutrition then their thrifty phenotype is a disadvantage and is associated with obesity and insulin resistance later in life (Fernandez-Twinn and Ozanne, 2006). In something of a paradox, a higher birthweight is also associated with higher BMI in later life. The explanation for this association is unclear but is likely to be a combination of genetic and pre- and post-natal environmental factors (Oken and Gillman, 2003). Studies of the offspring of diabetic mothers have proposed that high glucose levels in the mother can cross the placenta causing the foetus to produce insulin which acts as a foetal growth hormone. However the mechanism through which this induces long term changes in the foetus, and the importance of this pathway in non-diabetic mothers, is not yet clear (Oken and Gillman, 2003).

In infancy, breastfeeding is associated with a lower risk of obesity in childhood and adolescence (Arenz et al., 2004, Owen et al., 2005). It is postulated that breast-fed infants may be more in control of how much milk they consume compared to bottle-fed infants and this may result in better self-regulation of energy intake as they grow older, or it could be due to lower insulin concentrations in breast milk. However it is also possible that factors associated both with obesity and feeding method confound the association. A further period in childhood associated with the development of obesity is adiposity rebound; this is the point between the ages of 3 to 7 yrs when a child's BMI reaches a nadir then begins to rise again. The timing of adiposity rebound is inversely associated with BMI/obesity in later life but the mechanism is not known (Rolland-Cachera et al., 2006).

Additional risk factors for childhood obesity include parental adiposity, pubertal timing, levels of physical and sedentary activity, and the consumption of energy dense food (Kipping et al., 2008). Maternal overweight is a correlate of overweight and obesity in late adolescence (Koupil and Toivanen, 2008, Kowaleski-Jones et al., 2010). This association could reflect both shared genetics and environment. Puberty is a period of rapid change in body shape and size. The timing of puberty varies widely, and there is an age range of 4-5yrs during which it is considered normal for puberty to start (Parent, 2003). The mechanism through which puberty is initiated is complex and still not fully understood (Pinyerd, 2005; Aksglaede, 2009). Many studies have found childhood obesity to be associated with early puberty in girls but results are mixed for boys (Adair and Gordon-Larsen, 2001, Akslaede et al., 2009, Freedman et al., 2003, Kaplowitz et al., 2001, Wang, 2002). The direction of causation in this association has been debated (i.e. does obesity cause early puberty or does early puberty cause obesity). Although more longitudinal research is needed, a recent review of studies concluded that "the evidence to date suggests that obesity may be causally related to earlier puberty in girls rather than earlier puberty causes an increase in body fat…. in contrast, few studies have found a link between body fat and early puberty in boys" (Kaplowitz, 2008, p5208).

Although 25-40% of BMI is thought to be determined by genetics, the large increase in overweight and obesity in recent years cannot be explained by changes in the gene pool and therefore determinants of changes in the energy balance must be the primary cause (Anderson and Butcher, 2006). However reviews of studies of energy consumption and expenditure in childhood have failed to reach a consensus on the main drivers of overweight and obesity (Anderson and Butcher, 2006, Bleich et al., 2010). Evidence for a secular increase in energy intake is mixed, and a lack of relevant data has precluded conclusions about trends over time in energy expenditure (Bleich et al., 2010). Sugary drink consumption has increased and studies have generally found this to be related to total calorie consumption and overweight (Anderson and Butcher, 2006). Conversely, although many snack foods are energy dense, studies have not found snacking to increase obesity. Fast food consumption has been associated with greater total calorie intake but findings for an association with obesity have been mixed. There is no clear pattern between fruit and vegetable consumption and obesity in children and adolescents (Ledoux et al., 2011). In a systematic review of mainly cross-sectional studies, higher levels of habitual activity were associated with lower levels of obesity (Jimenez-Pavon et al., 2010). Methodological differences likely contribute to the mixed findings of the energy expenditure and intake studies (e.g. study design, sample characteristics, measures of diet and activity, measures of body size). Energy intake and expenditure are difficult to measure accurately and many studies rely on self-report. Overall, there is insufficient evidence on whether it is energy intake, expenditure, or both which is responsible for increases in child and adolescent obesity (Anderson and Butcher, 2006, Bleich et al., 2010).

Individual behaviours related to obesity and CVD (e.g. diet, physical activity) are shaped and constrained by upstream determinants including economic and social resources (Braveman et al., 2011). Socio-economic status (SES) is inversely associated with obesity for women in developed countries, although this relationship may have attenuated slightly in recent years (McLaren, 2007, Sobal and Stunkard, 1989). This suggests the presence of upstream social influences which encourage obesogenic behaviours in individuals across the SES spectrum (McLaren, 2007). Consistent patterns between SES and obesity in men have not been found (McLaren, 2007, Sobal and Stunkard, 1989). Childhood SES is not associated with obesity in adulthood for men, but it is for women although much of the association may be mediated by adult SES and other obesity related factors (Senese et al., 2009). In adolescence low SES is associated with poorer diets (less fruit and vegetables, more fat and sugar) and less physical activity (Hanson and Chen, 2007). Both childhood and adulthood SES are associated with developing and dying from CVD; rates of CVD increase with decreasing SES in most developed countries, and although CVD rates in many countries are declining these differences are generally persisting (Galobardes et al., 2006, Harper et al., 2011, Mackenbach et al., 2000).

Several mechanisms through which SES could influence health have been proposed (Braveman et al., 2011). More educated individuals may be better informed about healthy lifestyle choices, and may place more importance on health than those with less education. Those with higher incomes have resources to make healthier choices, for example in terms of diet or physical activity. SES is also related to psychosocial stressors and these are associated with overweight and obesity in both children and adults (Dallman, 2010, Gundersen et al., 2011). Relative rather than absolute deprivation may also be an important source of psychosocial stress (Wilkinson and Pickett, 2007). Adults of low SES may have more stress in their lives through financial worries, unemployment, low status jobs, or social isolation (Hemingway et al., 2001). Stressors in childhood can include household circumstances (e.g. parental divorce, or poor mental or physical health of family members) and school circumstances (e.g. bullying, exam stress). In times of stress people are more likely to choose high fat and sugar foods, and often increase their total calorie intake (Dallman, 2010). This could be by stress influencing biological controls related to appetite or through stressful situations resulting in less time to purchase and prepare healthy food (Dallman, 2010, Zinn and Palmer, 2010). The impact of psychosocial stress on obesity risk may be particularly important for young people living in deprived homes where stressors are more common (Gundersen et al., 2011).

There is growing interest in how wider upstream determinants, such as neighbourhood context, could contribute to the social patterning of obesity and related behaviours in childhood (Maziak et al., 2008). For example, children in disadvantaged areas may have no where safe to play outside, or may live in areas where it is difficult to buy healthy food (Hanson and Chen, 2007). It is these contextual characteristics which are the focus of this thesis and these will be discussed in detail in Section 1.2.

1.1.5 Potential explanations for ethnic differences in obesity

Racial/biological

The racial argument proposes that racial differences in disease risk are due to genetic differences between groups. However the relationship between genetics and race is complex, not least because genetic boundaries between different racial groups are not discrete, and there is considerable genetic heterogeneity within ethnic groups (Bamshad et al., 2004). The contribution of genetics to between individual variation in obesity has been estimated at 40-70%, but few candidate genes have been identified. Of those that have, effect sizes on BMI and obesity risk are small (Loos, 2009). The largest effect identified to date is for the FTO gene; each copy of the risk allele increases BMI by 0.26 to 0.66 kg/m^2 in Europeans but does not seem to have the same effect size on South Asians, Africans, or African Americans (Loos, 2009). The impact of obesity genetic variants on phenotype is not necessarily fixed. A gene-environment interaction has been found between the FTO gene and activity levels; the effect of the risk allele is stronger in sedentary individuals and attenuated in those who are physical active (Loos, 2009). Therefore although genes could contribute to ethnic differences in obesity and CVD risk their influence is likely to be small and their effects are not necessarily fixed; lifestyle factors (e.g. diet, exercise) can modify genetic susceptibility (Vimaleswaran and Loos, 2010).

A further strong argument against genetics being the driver of ethnic differences in obesity and CVD is that morbidity and mortality rates for people of similar ancestry differ widely depending on their environment. Populations with similar genetic predispositions living in different environments have substantially different obesity levels (Vimaleswaran and Loos, 2010). CHD and CVD rates also differ widely between individuals of the same ethnicity living in different settings; for example Japanese people living in Japan have lower CHD rates than their counterparts in California, and South Asian migrants in Australia have significantly lower CVD mortality than the Australian born population whereas South Asians in the UK have higher CVD mortality than the UK born population (Gray et al., 2007, Marmot et al., 1975). Australia is a low CHD mortality country compared to the UK therefore the contrast in CVD mortality of South Asians in the UK compared to those in Australia is striking. The convergence of CVD risk from that of the country of origin to that of the new country is further evidence that susceptibility to disease is not fixed. In the first study of migrant mortality in the UK, Marmot found that mortality rates in the migrant groups were intermediate between those of the original country and those of the new country (Marmot et al., 1984). The heterogeneity in disease risk *within* ethnic groups is further evidence against the racial argument. Disease risks differ within group by social class and by known CVD risk behaviours (e.g. smoking, unhealthy diet) (Chaturvedi, 2003, Marmot et al., 1984). Therefore although genetic susceptibility may play a role in influencing obesity or CVD risk, the social patterning of risk factors is likely to be more important in determining ethnic inequalities in obesity and related diseases.

Foetal growth

Ethnic differences in foetal growth could contribute to ethnic differences in CVD and obesity in adulthood. South Asian, Black Caribbean and Black African babies in the UK have a lower mean birthweight and are more likely to be low birthweight than White babies; many of these differences are explained by socio-economic status or maternal and infant characteristics (e.g. gestational age, mother's height and age, pregnancy complications) (Chowdhury et al., 2000, Kelly et al., 2009). In the US Black, Asian and Hispanic babies are lighter than White babies but these differences were not explained by factors associated with low birth weight such as smoking, parity, or prenatal care (Shiono et al., 1986).

Socio-economic status

Ethnic minority groups in the UK are often economically disadvantaged relative to the majority population (Nazroo, 1997, ONS, 2011). Non-White ethnic groups generally have higher unemployment rates and higher economic inactivity (not available for work/not seeking work) than the White British. Pakistanis and Bangladeshis are the most likely to live in overcrowded homes (South Asian families have the largest household sizes). Bangladeshi, Black Caribbean and Pakistani groups are the least likely to have a university degree. However not all ethnic minority groups are disadvantaged; Indians in the UK are more likely than any other group, including the White UK, to own their own home and rates are also high for Pakistanis (Black Africans are the least likely). Indians are also more likely to have a university degree than Whites. It is also important to note that there is considerable SES heterogeneity within each ethnic group. The circumstances surrounding migration, length of time in the UK, and generational status could all impact on current SES.

The structural argument proposes that the poorer health of many ethnic groups is due to their lower SES (Nazroo, 1998). This initially was dismissed as a cause due to a lack of class mortality gradients within ethnic groups in the UK in the 1970s (Marmot et al., 1984, Nazroo, 2003, Williams et al., 1998), however by the 1990s a gradient similar to that seen in the general population had emerged (Harding and Maxwell, 1997, Nazroo, 1997). It can now be concluded that there is evidence of social patterning of health within ethnic groups (Nazroo, 2003). Therefore given that many ethnic minorities are of low SES, controlling for measures of social class often attenuates ethnic differences in health; but it does not generally remove them (Dressler et al., 2005, Nazroo, 2003). Rather than this being evidence of an 'ethnic effect' over and above SES, it could be due to standard measures of class not accurately measuring the position of ethnic minorities (Braveman et al., 2005, Nazroo, 1998).

Within a given social class or educational level, ethnic minorities have lower incomes than Whites (Braveman et al., 2005, Lillie-Blanton and Laveist, 1996, Nazroo, 1997), and may do the less favoured jobs within each class (Williams et al., 1998). Compared to people in the general population earning a similar income, they may have less available money due to remittances sent to support family in their home country (Williams et al., 1998). Furthermore, a single measure of class based on occupation in the host country may poorly reflect economic opportunities and resources over the lifecourse (Williams et al., 1998). For example, migration to a new country can be followed by a period of de-skilling, where migrants take lower status jobs than they had in their home country. Therefore standard measures of SES are not suited to 'controlling out' effects of SES differences between ethnic groups (Nazroo, 1998).

Other measures of disadvantage may be more important in explaining ethnic health inequalities than traditional measures of SES. For example psychosocial stress, which is associated with obesity and CHD, could be important. The process of migration and establishing a new life in a new country can be sources of stress (Marmot et al., 1984). Racism and discrimination can also cause stress and result in ethnic minorities feeling excluded and disadvantaged compared to others (Nazroo, 2003). South Asians reported more psychosocial stress than Whites (e.g. less job control, less social support at work, more crowded homes, more racial harassment) (Hemingway et al., 2001, Williams et al., 2007). Differences between Black Caribbeans and Whites in psychosocial stressors were inconsistent (Hemingway et al., 2001).

It is important to consider that SES, however it is measured, is not merely a confounder in the relationship between ethnicity and health, but rather part of the causal pathway (Williams, 1999). Discrimination and marginalisation of ethnic groups, often over long periods of time, has resulted in their lower SES. Racism can be at an institutional level as well as an individual behaviour. Therefore SES should not be viewed as an explanation of ethnic differences, as to do so implies that the lower SES of ethnic minorities is inevitable rather than being the result of social and political processes both current and historical.

Culture

Cultural traditions could be important determinants of health and health behaviours, for example in influencing diet, or smoking behaviours (Smith et al., 2000). However cultural beliefs and behaviours are not fixed and change over time and by context. The process of acculturation, through which individuals integrate or assimilate into their new environment, may result in changes to cultural traditions (Berry, 1997). Furthermore, ethnicity is only one aspect of an individual's identity; other characteristics such as age, gender, or education could be as or more important (Nazroo, 1998).

Physical activity and diet

The HSE 2004 reported on physical activity and dietary behaviours in ethnic minority groups and the general population (ONS and NatCen, 2006). Ethnic minorities were generally less active than the general population. Indian, Pakistani and Bangladeshi men and women were less likely to meet physical activity recommendations than the general population. Between 1999 and 2004 the proportion of people in the general population meeting the guidelines increased but this was not observed in ethnic minority groups with the exception of Indian women. With the exception of Black Caribbean men, participation in any moderate activity in the month prior to survey was lower in ethnic minority groups than the general population. In children, Pakistani boys were as likely as their peers in the general population to meet recommended levels of activity but children in other minority groups were less likely. Men and women from the South Asian groups, the Black Caribbeans and Africans were all more likely to consume the recommended 5 or more portions a day of fruit and vegetables, with levels being highest for the Indians. These ethnic minority groups, with the exception of Pakistani women, also had lower fat intake than the general population, with Indians having the lowest fat intake. In children, ethnic minorities were more likely to eat 5 or more portions of fruit and vegetables with the exception of Bangladeshi girls for whom proportions were similar to the general population.

In DASH, at 11-13yrs there were no significant ethnic differences in the proportion of children eating ≥5 proportions of fruit and vegetables per day (Harding et al., 2008b). Indian girls were significantly less likely to eat <1 portion per day compared to their White UK peers. The proportion reporting drinking fizzy drinks every day was high in all groups, particularly for boys. Of the boys, the Pakistani/Bangladeshis reported the highest levels, and of the girls it was the Black Caribbeans. The Black African boys and girls were significantly less likely than their White peers to eat breakfast everyday, in contrast the Indians were significantly more likely. Black African boys were significantly more likely to be in the most active group. The Black African boys and girls, and the Black Caribbean boys, were least likely to be in the low activity group. Although HABITS also had diet and activity data this was not reported by ethnicity (Wardle et al., 2003).

Neighbourhood context

Ethnic minorities are often spatially clustered and characteristics of their residential neighbourhoods may affect their health (Nazroo, 1998). It is increasingly recognised that in order to understand ethnic differences in health and health behaviours, the context in which different ethnic groups live needs to be understood (Karlsen et al., 2002, Kumanyika, 2008). In the next section the ways in which neighbourhoods could affect health is considered, and the potential importance of neighbourhoods to ethnic inequalities in health is discussed in Section 1.3.3.

1.2 Neighbourhoods and health overview

1.2.1 Context versus composition

Health is spatially patterned; populations of different areas are not equal with respect to their health and health behaviours (Bernard et al., 2007). These spatial variations in health ‘exist at many scales from the global to the local’ (Flowerdew et al., 2008, p1241) however much interest has focused on neighbourhoods of residence, and interest on neighbourhood effects on health and health behaviours has increased substantially in the last decade (Diez-Roux, 2001, Rahman et al., 2011). Some of the differences between neighbourhoods are likely to be due to different types of people living in different areas (the compositional argument), however studies on a range of health outcomes have shown that features of a neighbourhood can have an independent effect on health, over and above any effects from individual characteristics (the contextual argument). As context and composition are often inter-related, it has been said that to view them as opposing arguments is a ‘false dichotomy’ and ignores potential interactions between neighbourhood and individual level characteristics (Cummins et al., 2007, Macintyre and Ellaway, 2000). For example, people living in an area with poor resources may not all be equally affected; those with more money may be able to ameliorate any negative influences (e.g. they may own a car which allows them to access resources further afield). Not only are individual and contextual factors often highly related, the composition of an area actually creates context. Individuals ‘create context for their neighbours’; one person’s individual characteristics are another person’s context (Cummins et al., 2007). The example given by Flowerdew (2008) is that an individual living in an area with few shops selling fresh produce may have a lower intake of fruit and vegetables than an individual living in an area with lots of grocers. However, it could be other individuals in the neighbourhood who are creating this context through their shopping habits; if they do not want to spend money on fresh produce then shop owners will not open businesses there.

1.2.2 Mechanisms through which neighbourhoods could affect health and health behaviours

A variety of models have been proposed to explain contextual effects on health and health behaviours. One of these, the ANGELO framework (analysis grid for environments linked to obesity), was designed as a conceptual model to help understand how environments could be obesogenic (obesity promoting) or leptogenic (promoting leanness) via effects on food choices and physical activity (Swinburn et al., 1999). This model splits the neighbourhood into different domains: physical, economic, socio-cultural, and political. Some other models define only social and physical domains, with the latter sometimes being split into built (i.e. man-made) and natural.

Neighbourhood resources (e.g. parks, public transport, supermarkets) are a mechanism through which context could affect health (Crane, 1991, Flowerdew et al., 2008, Leventhal and Brooks-Gunn, 2000). Other features of the built environment, such as street lighting and pavements, could also influence health behaviours (Swinburn et al., 1999). However neighbourhoods are more than just ‘pools of resources for living and health’ (Bernard et al., 2007). The importance of accessibility, affordability, and quality of the resources, rather than just their physical presence has been emphasised (Bernard et al., 2007, Leventhal and Brooks-Gunn, 2000). The economic domain of the ANGELO framework includes pricing policies (e.g. for gym membership, public transport, or healthy foods) or budget allocations (e.g. for health promotion campaigns or bicycle tracks) and is therefore related to resource accessibility (Swinburn et al., 1999).

The dominant social and cultural norms in an area could also influence behaviours (Flowerdew et al., 2008). The sociocultural environment is affected by the characteristics of the individuals in it, including their sex, age, ethnicity, traditions and religion. These characteristics come together to form the norms and beliefs of an environment. Despite being difficult to measure, Swinburn et al. (1999) state that the sociocultural environment’s ‘impact on behaviour related to food and physical activity should not be ignored in any comprehensive analysis of environmental factors influencing obesity’. The contagion/epidemic models assume that behaviours can be ‘contagious’ and operate through peer influences (Chuang et al., 2005). For example, seeing others exercising in the neighbourhood may encourage physical activity and this could be a linear or threshold effect (Diez-Roux, 2001). According to the threshold model, if the prevalence of a behaviour goes above a certain 'tipping-point' then the process of spread will increase greatly, whereas below the tipping-point the levels will 'gravitate towards a low level equilibrium' (Crane, 1991).

Crime, fear of crime, and physical and social disorder can deter people from using neighbourhood resources, and reduce social capital (Loukaitou-Sideris and Eck, 2007). An area's reputation can also impact on how people view and use their area. In addition, living in a stressful neighbourhood can negatively impact on health via psychosocial pathways. For example, neighbourhood stressors and hazards (e.g. high density housing, drug disorder, street crime, lack of green space, violence) have been associated with both increased blood pressure (Agyemang et al., 2007) and cardiovascular disease (Augustin et al., 2008, Sundquist et al., 2006).

It is unlikely that everyone will be equally affected by their neighbourhood (Macintyre and Ellaway, 2000). For example, effects are likely to vary by individual SES, and how 'area-bound' an individual is. Area-bound refers to the fact that some people, such as the elderly and unemployed, spend more of their time in their neighbourhood than others, and hence have higher exposure to that context. The influence of the neighbourhood context is also likely to differ between children and adults. For younger children, the neighbourhood may have less direct effects on behaviour; they may have limited access to neighbourhoods and other contexts. Instead, neighbourhood effects are likely to be mediated by their parents who are 'advocates or brokers for their children's receipt of community resources' (Leventhal and Brooks-Gunn, 2000). Parenting styles could also be a mediator through which neighbourhood effects influence children. Parents in deprived areas restrict where their children can go in order to reduce exposure to neighbourhood influences, particularly their peers (Leventhal and Brooks-Gunn, 2000).

Parents who live in an area with poor resources may use 'resource-seeking strategies', often meaning they will access resources from outwith their own neighbourhood for their children (Leventhal and Brooks-Gunn, 2000). Therefore, it is not just the area itself, but what surrounds it that could be important for health. These include family connections, or resources such as churches and schools (Chuang et al., 2005).

1.2.3 Ethnicity and neighbourhood effects

Neighbourhood effects can differ, and be modified, by ethnicity. Ethnic density is a neighbourhood characteristic which may promote health through the social environment; social cohesion and support, religious groups, and community norms may attenuate stressors such as racism or deprivation (Karlsen et al., 2002). In addition, ethnically homogenous neighbourhoods may have more ethnic-specific resources such as shops that sell traditional foods, or places of worship (Cummins et al., 2007, Lee and Cubbin, 2002). Studies have found that in terms of psychosocial health, for a given ethnic group, living in an area with a moderate concentration of that group may be beneficial but very high concentrations could have a detrimental effect (Cummins et al., 2007).

Ethnic minorities, particularly new migrants, may not be economically poor and may be in good health. This 'healthy migrant effect' is because those migrating are often healthier and have more resources than those who do not migrate. However these migrants may choose to settle in areas seen as undesirable by others (e.g. deprived, high levels of crime) because there are already high concentrations of their own ethnic group living there. This potentially provides them with access to more social and structural resources (Bernard et al., 2007). However deprived areas with social and physical disorder can be stressful places to live and negative effects on health have been demonstrated.

Ethnic minorities in the UK are concentrated in urban areas, predominately London and the West Midlands. They tend to live in more deprived areas than White people and more than half live in wards where over 40% of the population are ethnic minorities (Owen, 1994). However there are differences between the ethnic groups; Pakistanis and Bangladeshis are the most likely to live in the most deprived areas and to live in areas with the highest concentrations of ethnic minorities (Dorsett, 1998). In London, Indians live in areas with less deprivation than White people but Indians in the West Midlands live in more deprived areas than White people. Bangladeshis and Black Caribbeans are the most likely to live in the most deprived areas of London. Ethnic minorities who are more recent migrants, those who are not fluent in English, and those with lower incomes and less education are more likely to live in areas with higher concentrations of ethnic minorities (Dorsett, 1998). White people in the UK tend to live in areas with low ethnic minority concentration irrespective of their individual deprivation level. Despite this the UK does not have the high degree of residential segregation seen in parts of the US. In the US housing policies have contributed to the existence of deprived neighbourhoods and residential segregation by ethnic group. This has resulted in African Americans being concentrated in poor urban neighbourhoods and European Americans in relatively affluent areas outwith cities. African American children are six times less likely than European American children to live in an affluent neighbourhood, and ten times more likely to live in a poor neighbourhood (Leventhal and Brooks-Gunn, 2000).

Neighbourhood resources may be perceived as belonging to a particular ethnic group, and as such ethnicity can play a role in the accessibility of resources (Leventhal and Brooks-Gunn, 2000) and ethnic minorities may have greater fears for their safety resulting in less access to neighbourhood resources (Loukaitou-Sideris and Eck, 2007). In the US residential segregation is apparent even among those living in relatively wealthy areas; African Americans who live in affluent neighbourhoods are generally not living in the same affluent areas as Whites. For example, the affluent areas lived in by European Americans are more likely to be surrounded by other affluent areas. In contrast, the affluent neighbourhoods that African Americans live in are more likely to be surrounded by deprived areas (Leventhal and Brooks-Gunn, 2000). Therefore, the benefits of living in an affluent area may differ for European and African American children.

1.2.4 Conceptualising neighbourhoods

Conventionally, neighbourhoods have been defined as physical spaces with defined borders and fixed in time (Cummins et al., 2007, Galster, 2001). Many studies have used geographical data units, such as wards or super output areas (UK) or census tracts (USA), to define neighbourhoods as they are geographically distinct and data at these levels are easily accessible. However, these units may not correspond with anything the residents perceive as being their neighbourhood (Flowerdew et al., 2008).

In contrast to these conventional approaches, the relational approach views space as being 'unstructured, unbounded and freely connected' (Cummins et al., 2007, p1827). Proponents of the relational approach argue that people are mobile, both in everyday life and over their lifecourse. Therefore people are not influenced by a single bounded space; they are exposed to characteristics of multiple places. This can be due to their own movements, or due to a particular place itself changing over time. As a consequence, it is not possible to define one physical boundary that is relevant for all neighbourhood characteristics (Galster, 2001).

If health can be affected by context then 'it is not reasonable to expect that it will be identifiable regardless of how the neighbourhood is defined' (Flowerdew et al., 2008, 1243). The 'modifiable area unit problem' refers to the fact that the results of analyses can depend on how data are aggregated. Most studies assessing the relative importance of contextual and compositional factors on health have found compositional effects to be larger (Flowerdew et al., 2008). However this could be due to neighbourhoods not being defined in a valid way.

1.3 Contextual influences on body size and related behaviours in children and adolescents

This section first reviews the evidence for neighbourhood effects on the obesity related behaviours diet and physical activity in children and adolescents. It then summarises the evidence to date of neighbourhood effects on child and adolescent body size.

1.3.1 Neighbourhood influences on physical activity

Physical activities can be conceptualised as being either recreational or for active transportation, and neighbourhood characteristics have been hypothesised to influence both of these types of activity (Sallis and Glanz, 2006). Active transportation includes walking and cycling; children and adolescents could use active transportation for their commute to school or to visit other locations in their neighbourhoods. Both the physical and social environments could affect young people's physical activity levels through providing places to be active, facilitating active transportation, or through the influence of social norms. The social and built environments are not mutually exclusive and could positively reinforce each other. Areas with residents with more positive attitudes to physical activity may have better facilities because the residents invest more time and money in them; in turn the presence of better resourced and maintained facilities may encourage positive attitudes and norms towards physical activity in the residents.

1.3.1.1 Recreational activity

Several review papers have summarised the evidence for an association between children and adolescent's physical activity levels and neighbourhood opportunities to exercise. The majority, including a recent 'review of reviews', have concluded that the presence of facilities and clubs for physical activity and sports is positively associated with more activity (Davison and Lawson, 2006, de Vet et al., 2011, Limstrand, 2008, Sallis et al., 2000). Many of the studies used perceptions of facilities rather than objective measures. A positive association between parks and playgrounds and physical activity levels was also found (Limstrand, 2008).

Studies published more recently confirm this positive relationship between activity levels and the presence of facilities and parks. For example, in a New-Zealand based study Utter et al. (2006) found that students who perceived that there were certain facilities (a park, skateboard ramp, sports field, swimming pool, gym, or bicycle track) in their area were significantly more likely to perform regular vigorous activity, independent of age, gender, ethnicity, and SES. Another study found that those who used recreation centres were more active than those who did not. However as this study asked about use rather than availability, it could be that more active people were more likely to attend the centres and this could have resulted in the association with activity being observed, rather than because the recreation centres themselves were responsible for raising activity levels (Gordon-Larsen et al., 2000). Adolescents who said there was nothing to do in their neighbourhood were significantly less likely to be active (Utter et al., 2006).

Quality in addition to the physical presence of facilities is important; dilapidated buildings and poor quality or unsafe equipment could all discourage the use of facilities. One study found physical activity was associated with better quality facilities but not with the quantity of facilities available (Romero, 2005). Physical accessibility is another consideration (Sallis and Glanz, 2006). Facilities could be geographically close to home but individuals may be discouraged from travelling to them because of busy traffic, a lack of street lighting, or high levels of crime for example. Social norms could be important in influencing whether children in a neighbourhood use the facilities on offer although few studies have included measures of this (de Vet et al., 2011). In the US, ethnicity has also been found to play a role in accessibility due to some resources being dominated by individuals of a particular ethnic group which deters people of other ethnic groups from using them (Leventhal and Brooks-Gunn, 2000). Costs and opening times could also be barriers for some neighbourhood residents. In a study of adolescents living in a low-income area, few reported difficulties with physical access to facilities, however more than half reported that their parents would not pay fees to access facilities, and many wrongly thought there were entrance fees to facilities which were actually free (Romero, 2005).

It has been hypothesised that perceptions of neighbourhood safety, objective measures of crime, and measures of disorder could influence activity levels. Road safety could be important, particularly for young children, in a parent's decision to allow their child to access facilities in the neighbourhood themselves and for making a neighbourhood pleasant to walk and play in. Only a few studies have examined measures of road safety and activity levels in children thus making firm conclusions difficult. However the presence of pavements, low levels of traffic, and access to crossings have been shown to be positively associated with increased levels of physical activity (Limstrand, 2008).

Increasing levels of crime (measured objectively) were associated with lower levels of activity in adolescents in most of the small number of studies that have examined this measure (Ferreira et al., 2006). For example, Gordon-Larsen et al. (2000) found that those in the highest crime areas were significantly less active than those in the lowest crime areas. Objective measures of neighbourhood deprivation have not been included in many studies, but one found it to be associated with lower activity levels in 11-12 year old girls but not boys (Brodersen et al., 2005).

Many more studies have included perceived measures of safety. The vast majority of these studies found no association between child or adolescent activity levels and parental or child-reported perceptions of safety (Davison and Lawson, 2006, Ferreira et al., 2006). For example, Motl et al. (2006) did not find any direct effects between safety and activity levels. However, this could be partly due to the fact that there was little variation in perceptions of safety within the sample, with the girls in the study generally feeling that their neighbourhoods were safe. It is possible that safe neighbourhoods do not promote physical activity, rather that unsafe areas may deter it. A study by Utter et al. (2006) did find an association; those who said they felt safe in their neighbourhood were significantly more active than those who did not. Perceptions of safety can differ by ethnicity; in one study White girls in urban areas felt it was safer to walk/jog alone than White girls in rural areas but there was no difference between Black girls in the two settings (Felton et al., 2002). In this study the White urban girls reported the highest levels of neighbourhood safety and they were also the group with the highest activity levels, however the association between perceptions of neighbourhood safety and activity levels was not formally tested.

US-based studies have examined neighbourhood disorder and found mixed results. In one study, lower levels of activity were reported by adolescents who lived in an area with more physical (e.g. graffiti, litter) and social (e.g. people selling drugs) disorder (Molnar et al., 2004). A further study found pleasant neighbourhood aesthetics to be associated with increased activity in adolescents (Mota et al., 2005). However Romero et al. (2001) found that perceptions of hazards in the neighbourhood were not significantly associated with perceptions of safety, and that those who perceived more hazards in the neighbourhood were actually more likely to be active. Perceptions that a facility was in a safe place or that it was safe to walk to it were not significantly associated with activity levels in fully adjusted models.

The lower levels of physical activity in residents of more socially deprived areas could be partly explained by less access to places to be active than those in more affluent areas. It has been hypothesised that low-income neighbourhoods have fewer resources for physical activity, and that any facilities present will be of lower quality than those in more affluent areas (Romero, 2005). In addition, residents of poorer areas may have limited resources to access facilities that cost money, or to travel to those located further afield (Lamb et al., 2010). Objective, country-wide studies of the distribution of neighbourhood facilities for physical activity have been conducted in Scotland, the US, and New Zealand. In Scotland, after adjustment for urbanicity the most affluent and most deprived areas had the lowest mean number of total facilities, and middle income areas the highest. The type of facility differed by neighbourhood deprivation; the most deprived neighbourhoods had the fewest private facilities, whereas the most affluent neighbourhoods had the fewest public facilities (Lamb et al., 2010). This study then examined total number of facilities within cities by neighbourhood deprivation; in Aberdeen and Dundee the most deprived areas had the lowest mean number of facilities per 1000 residents, whereas those in middle income areas tended to have the most. However in Edinburgh and Glasgow total number of facilities did not differ significantly by neighbourhood deprivation. Although total number of facilities did not vary, the type may have; a further Glasgow study found that affluent areas had more tennis courts, bowling greens and private swimming pools, but deprived areas had more public sports centres and public swimming pools (Macintyre et al., 2008).

In New Zealand, median travel time to the nearest park and sports or leisure facility was lower in more deprived neighbourhoods than in more affluent ones, although travel time to the nearest beach was highest for the most disadvantaged communities (Pearce et al., 2007). In the US, neighbourhood median income was positively associated with the likelihood of a neighbourhood having each of the four types of physical activity facility considered (physical fitness facilities, membership sports clubs, dance facilities and public golf courses) (Powell et al., 2006). In addition, these facilities were significantly less likely to be in neighbourhoods with high proportions of African Americans or Hispanics, and were more likely to be found in suburban as opposed to urban areas. In a further US study which examined 'community recreational spaces', a higher neighbourhood poverty rate was associated with lower availability of sports areas, parks/green spaces and bike paths. Areas with higher proportions of African Americans had fewer sports areas, parks/green spaces and public pools/beaches. In contrast, neighbourhoods with higher concentrations of Hispanics had greater availability of all types of recreational space. All facilities combined, areas with lower poverty rates, lower proportions of African Americans, and higher proportions of Hispanics had more recreational spaces (Powell et al., 2004). However another US study of girls reported no significant difference in access to parks and gyms by ethnicity or neighbourhood type. However in this study all of the girls (whether Black or White, or living in urban or rural areas) reported relatively low availability of play grounds, parks and gyms close to home (Felton et al., 2002).

Play areas (i.e. outdoor areas with play equipment such as swings and slides) may be important for activity in children, particularly for those without a private garden at home. In Glasgow there was a linear increase in the mean number of play areas with increasing neighbourhood deprivation (Ellaway et al., 2007). However a quality audit of a sample of play areas in Glasgow found that equipment was often poorer in more deprived areas (McAdam, 2010). Furthermore, in a focus group children in deprived areas reported more barriers to play, and these were of a more serious nature than those reported by children in more affluent neighbourhoods (barriers included vandalism, misuse of equipment, and safety from injury and strangers) (McAdam, 2010). A qualitative study of Glasgow residents cited social cohesion, integration and inclusion to be important in their decision of whether or not to use urban parks (Seaman et al., 2010).

Therefore the majority of studies have examined the physical presence of facilities rather than accessibility or quality (Powell et al., 2006). It is unclear whether perceived or objective measures are most important in determining behaviour. There may be facilities in a neighbourhood that residents do not perceive to be close to home; a study of parks in

Glasgow found poor agreement between measured and self-reported distance from home (Macintyre et al., 2008).

1.3.1.2 Active transportation

Active transportation is an important source of physical activity for young people; children and adolescents who walk or cycle to school are more likely to be fitter and meet physical activity recommendations than those who travel by car. Studies to date have not shown an association between active commuting and children's BMI (Davison et al., 2008).

There are a number of neighbourhood characteristics which are hypothesised to either facilitate of discourage active transportation. 'Traditional' neighbourhoods which were built before car usage became widespread (generally before the middle of the 20th century) were designed to be pedestrian friendly (Sallis and Glanz, 2006). Streets are well-connected, often in a grid-like pattern with lots of intersections, meaning pedestrians have a direct route to their destination. Mixed land use in these traditional neighbourhoods means that people live near to places to work, shop, and spend their leisure time; thus there are many destinations within walking distance of home. Related to this is population density; the relatively high residential density of traditional neighbourhoods (for example plenty of flats and apartments) makes local services viable.

In the later part of the 20th century, the growth of car ownership resulted in the creation of new residential suburbs (Sallis and Glanz, 2006). Streets in these neighbourhoods often have poor connectivity, consisting of long blocks and cul-de-sacs. Detached housing and large gardens result in residential density levels too low to support local facilities and consequently there are often no destinations within walking distance of home. Furthermore, zoning restrictions often resulted in some areas being entirely for residential properties, others for commercial premises and so on. Therefore residents of these sprawling residential suburbs will generally travel by car to work or to access other services (Rahman, 2011).

Most research on the built environment and neighbourhood walkability has been conducted on adult populations. A recent review concluded that mixed land use and higher population density promote walking (Saelens and Handy, 2008). Some child studies have found similar results; in a US-based study of children aged 5-18yrs greater residential density, better street connectivity, and mixed land use were associated with more walking

(Kerr et al., 2007). Furthermore, neighbourhood characteristics were more strongly related to walking for White children than their non-White peers, those from higher income families, and those from families with a car. However other studies suggest associations may differ between young people and adults. For example although better street connectivity is generally associated with more walking in adults, some children's studies have found less connected streets to be associated with more activity, suggesting that cul-de-sacs and low-traffic roads could be places for children to play outdoors (Sallis and Glanz, 2006).

Although walking is beneficial to health, more walkable neighbourhoods could promote adverse health behaviours. Mixed land use could mean an abundance of unhealthy food sources within walking distance of home (neighbourhood influences on diet are discussed in detail in the next section). In an area in Wales where pupils currently have to walk along a grass verge next to a busy road which has no pavement, the local council plan to build a path to connect the school to residential and retail areas nearby. The retail area includes a McDonalds restaurant and this has led to criticism that the new 'McPath' will facilitate access to fast food at lunchtime (Morris, 2011).

The strongest predictor of active transportation to school is distance; young people are more likely to walk or cycle the closer they lived to their school (Davison et al., 2008). Smaller schools tend to be located in more residential, densely populated areas whereas larger schools tend to be located outwith residential areas; however studies using size as a proxy measure of location have not found consistent findings with activity levels (Davison and Lawson, 2006, Davison et al., 2008). In their review of correlates of active transportation, Davison et al. (2008) also identified physical and social neighbourhood determinants. Young people were more likely to walk or cycle when the route to school was direct and with few hills, and when neighbourhoods were classified as 'walkable' (as measured by presence of pavements, residential density, intersection density, and land use mix). Access to public transport was not generally associated with active transportation. Carver et al. (2005) found the presence of roaming dogs was associated with less walking and cycling in adolescents. Differences in rates of active commuting were found by school type in Australia, with pupils at private schools less likely to walk or cycle; this finding was not explained by private pupils travelling further to school or higher rates of car ownership (Merom et al., 2006).

Parents' perceptions of neighbourhood safety were positively associated with active transportation, as was a greater proportion of housing in a school's vicinity with windows facing the road (a measure of 'eyes on the street'). Findings for the relationship between active commuting and parents' perceptions of crime or concerns about strangers were inconsistent. One study suggested that social norms played a role; children were more likely to actively commute if their parents perceived that other children were doing so. Davison et al. (2008) conclude that parents' perceptions of the environment were stronger predictors than built environment characteristics thus meaning that 'changes to the physical environment are unlikely to affect children's active commuting patterns unless parents' concerns and attitudes are also addressed' (p5).

In the US, Hispanic and African American children are more likely to actively commute to school than their White peers, and those of low SES are more likely to walk or cycle than those of high SES (Davison et al., 2008, McDonald, 2008). McDonald (2008) found that ethnic differences in young people's rates of active transportation to school could be explained by household income, vehicle access, distance between home and school, and residential density. Ethnic minority groups were more likely to live close to their school; over a third of Hispanics and 22% of Blacks live within one mile of their school compared to 16% of Whites (McDonald, 2008).

Findings from a qualitative study support those from the quantitative studies; in focus groups adolescents stated the greatest barrier to actively commuting to school was distance and girls in particular mentioned safety related concerns. Lack of motivation to walk was also an issue as they perceived other non-active models of travel to be readily available (Hohepa et al., 2006).

The relationship between the neighbourhood environment and active commuting is likely to differ by age and sex but few studies have examined this (studies generally adjust for these covariates or cover a small age range). In the US boys are more likely to actively commute than girls which may reflect parents having different perceptions of neighbourhood safety depending on the gender of their child. With increasing age children become more independent and active transportation rates generally increase. However rates drop in later adolescence in the US and this is thought to be related to young people beginning to drive (legal from 16yrs in the US). In an Australian study the road environment within 800m of home (total length of local roads, intersection density, total length of walking tracks, number of speed humps, and number of pedestrian lights) was associated with active transportation in adolescent girls (11-13yrs) and moderate to vigorous physical activity in adolescent boys but no association were observed in children (8-9yrs) (Timperio et al., 2010).

1.3.1.3 Sedentary time

Sedentary behaviour is a distinct behaviour from physical activity; inactivity is not simply a lack of physical activity (Ferreira et al., 2006). There is often poor correlation between the two, for example no relationship was found between physical activity and time spent watching television or playing computer games (Gorely et al., 2004). Consequently activity and inactivity can have different determinants (Ferreira et al., 2006). It has been proposed that young people living in neighbourhoods with no safe places to play, heavy traffic, crime and graffiti will spend more time indoors being sedentary (Rahman et al., 2011). However there has been less research on this than on physical activity outcomes and reviews of correlates of sedentary behaviour and television watching have not included any studies which have examined neighbourhood characteristics (Gorely et al., 2004, van der Horst et al., 2007). Gorely et al. (2004) conclude in their review of correlates of television watching in young people that environmental determinants may be more important for physical activity and sociodemographic factors for inactivity.

However some studies examining neighbourhood correlates have been published, the majority being US-based, with an adolescent sample, and using self-reported sedentary outcomes (usually defined as watching TV/videos or playing computer games). The number of public sports pitches in the borough was associated with sedentary behaviour for girls but not boys (Brodersen et al., 2005). The relationship was in the opposite direction to what may be expected; more sports pitches were associated with more inactivity. The level of spending on sports facilities in the borough was not associated with inactivity (Brodersen et al., 2005). The distance to various retail and recreation facilities was not associated with inactivity (Norman et al., 2005).

Children in more affluent areas, measured by median income, were less sedentary than those in more deprived areas (MacLeod et al., 2008). However other studies found evidence of gender differences, with this relationship only being true for girls in one study (Brodersen et al., 2005), and only true for boys in another (Richmond et al., 2007).

Neighbourhood educational level was not associated with inactivity levels (Richmond et al., 2007).

There was no association between the proportion of the neighbourhood population who were White and inactivity levels for either boys or girls (Richmond et al., 2007). Overall there was little evidence of walkability being associated with sedentary behaviour. The exception being the presence of hills; this was a significant correlate of increased inactivity for girls (Norman et al., 2005). Girls living in urban areas watched more TV than those in rural areas, however this difference was not statistically significant (Felton et al., 2002). Higher objectively measured crime was associated with more inactivity. However, this was a significant association for both males and females in one of the studies (Richmond et al., 2007), but only for females in the other (Gordon-Larsen et al., 2000). No association was found between perceptions of neighbourhood safety and inactivity (Norman et al., 2005, Richmond et al., 2007).

Compared to their Black and Hispanic peers, White adolescents spent less time being sedentary and were more likely to live in low crime/safe areas, areas with higher incomes and more educated populations (Felton et al., 2002, Gordon-Larsen et al., 2000, MacLeod et al., 2008, Richmond et al., 2007). However only one study assessed whether neighbourhood characteristics explained any of the ethnic differences in sedentary behaviour (Richmond et al., 2007). Among girls, after controlling for neighbourhood characteristics there was no significant difference in inactivity between Hispanic and White girls. The difference between Black and White girls was attenuated but Black girls remained significantly more inactive. The level of violent crime was the only neighbourhood variable to be a significant correlate in the model. There was no significant difference between inactivity levels of White and Hispanic boys at baseline, and this remained the case in the models adjusting for individual and neighbourhood characteristics.

1.3.2 Neighbourhood influences on diet

Neighbourhood differences in access to foods may be an important influence on diet, and hence obesity levels. Neighbourhood effects on diet are thought to operate through two pathways linked to accessibility: access to foods for home consumption from supermarkets and grocery stores, and access to ready-made food for both home and out-of-home consumption from fast food outlets and convenience stores (Cummins, 2007).

Accessibility encompasses both the physical presence and the affordability of foods in a neighbourhood. Abundant sources of cheap, unhealthy foods and a lack of places to buy affordable, healthy foods may contribute to an unhealthy diet (Pearson et al., 2005). Different types of shops and restaurants vary in the food they sell, and the prices they charge. The geographical location of these different food sources could be an important determinant in who can access healthy food. Studies have shown that residents of deprived areas have poorer diets and higher obesity levels than residents of more affluent areas, even after adjustment for individual socio-economic circumstances. It has therefore been hypothesised that lack of access to healthy foods may explain why residents of poorer areas have less healthy diets (Beaulac et al., 2009).

Fast food restaurants in particular have been implicated in the obesity epidemic (Duffey et al., 2009). There has been a rise in the amount of food being consumed outside of the home, and much of this is fast food (Sharkey et al., 2011). Fast food is inexpensive, quick, and convenient but also energy dense, high in saturated fat, and of low nutritional value (Fraser et al., 2010). Energy density of foods is a key determinant of energy intake as humans are generally poor at recognising high calorie foods and so do not down-regulate the amount eaten in order to maintain an energy balance (Prentice and Jebb, 2003). Regular consumers of fast foods are therefore likely to unintentionally consume excess energy and subsequently gain weight.

Two recent systematic review of mainly US-based studies concluded that more deprived neighbourhoods and areas with higher ethnic minority concentrations tended to have more fast food outlets (Fleischhacker et al., 2011, Fraser et al., 2010). Studies have assessed both proximity (distance from home to nearest outlet) and coverage (number of outlets in a neighbourhood); hence people living in deprived areas had a shorter distance to travel to their nearest outlet, and a greater choice of fast food outlets in their area. In the one UK study which has examined ethnic minority concentration and fast food outlets in the UK higher ethnic minority concentration was associated with increased numbers of outlets (Molaodi et al., 2011b). In New Zealand there was a strong positive association between access to fast food outlets and area deprivation (Pearce et al., 2007). In both Scotland and England there was a positive, broadly linear association between neighbourhood deprivation and the number of fast food outlets per capita (Cummins et al., 2005b, Macdonald et al., 2007). However in a Glasgow-based study, unhealthy food outlets (fast food outlets and take-aways) were not more likely to be located in deprived areas, instead they were most commonly found in the city centre, and along main high ways; areas busy with workers, shoppers, students, night life and commuters. Few food outlets of any type were located in primarily residential areas, whether they be deprived peripheral housing estates or affluent areas in the city (Macintyre et al., 2005).

Traditional fast food outlets are not the only source of fast food in a neighbourhood; shops such as convenience stores are also important. Many shops have expanded the range of goods they sell to include fast foods in order to meet customer demand; therefore only considering fast food outlets underestimates the exposure of residents to fast foods (Sharkey et al., 2011). Convenience stores tend to sell pre-prepared, high calorie foods; the small amount of fresh produce that they do stock is generally expensive (Larson et al., 2009). In urban areas in the US, compared to middle-income neighbourhoods, low-income neighbourhoods had significantly more convenience stores and high-income neighbourhoods significantly fewer (Powell et al., 2007). Furthermore, Hispanic neighbourhoods had significantly fewer convenience stores than non-Hispanic neighbourhoods, but there was no difference between African American and White neighbourhoods. A Glasgow-based study of a range of food retailers (bakers, butchers, green grocers, fishmongers, convenience stores, supermarkets and delicatessens) found that the most deprived areas had the highest mean number of convenience stores per capita, but the second most affluent quintile had the second highest number. There was no significant difference by neighbourhood deprivation for the other types of food retailers. Overall, the most deprived neighbourhoods had the highest mean number of food retailers and the least deprived the lowest (Macdonald, 2009). Similarly, in the US high income neighbourhoods had fewer food stores (supermarkets, grocery stores, and convenience stores) than middle-income areas (Powell et al., 2007).

Supermarkets stock a wide range of goods including good quality fresh fruit and vegetables; costs tend to be lower than in other types of shop (Larson et al., 2009). The availability of supermarkets has been found to be associated with higher fruit and vegetable intake, healthier diets, and lower rates of obesity in the US (Powell et al., 2007). Poor supermarket access can result in residents having greater exposure to energy-dense food sold in convenience stores and fast food outlets (Walker et al., 2010). The term ‘food desert’ was coined to describe populated urban areas where residents do not have access to an affordable, healthy diet (Cummins and Macintyre, 2002, Hendrickson et al., 2006). Food deserts are of most concern in socio-economically disadvantaged areas as they may result in ‘deprivation amplification’; that is, neighbourhood disadvantage could amplify the adverse effects of individual disadvantage (Macintyre, 2007). More affluent individuals are likely to have a car which enables them to access healthy food from shops further from home. However for low-income individuals without access to a car and unable to afford costs associated with public transportation, their ability to access shops further-afield is limited (Beaulac et al., 2009). As food shopping involves carrying a large number of bags or making frequent trips the logistics of accessing healthy food can be difficult for low income individuals (Powell et al., 2007, Walker et al., 2010).

There is ‘abundant and robust’ evidence of food deserts in the US; people living in areas with low-incomes or high proportions of African Americans had poor access to healthy food (Beaulac et al., 2009, p4). Access to supermarkets was particularly poor for those living in neighbourhoods which were both African American and poor; on average residents of poor African American neighbourhoods lived more than a mile further from a supermarket than residents of poor White American neighbourhoods (Walker et al., 2010). Low income households tended to shop locally due to lack of transportation and hence ‘sacrificed cost and quality for convenience’ (Walker et al., 2010). There was therefore deprivation amplification as people who were already limited in their ability to purchase healthy food because of individual circumstances were further disadvantaged by structural inequalities in the food retail environment (Beaulac et al., 2009). There was mixed evidence on whether food prices were associated with neighbourhood disadvantage in the US (Beaulac et al., 2009). A US-wide study found low income neighbourhoods had fewer chain supermarkets than middle-income neighbourhoods (Powell et al., 2007). Furthermore, African American neighbourhoods had half the number of chain supermarkets that the White neighbourhoods had, and the Hispanic neighbourhoods had less than a third of the non-Hispanic neighbourhoods. In contrast, non-chain supermarkets and grocery stores (which tend to have higher prices and lower quality than the chain supermarkets) were more common in low income areas than middle-income areas, and in African American areas compared to White. Controlling for neighbourhood deprivation did not explain the large ethnic differences in access to chain supermarkets (i.e. although African Americans live disproportionately in poor areas this did not account for the lack of chain supermarkets in their neighbourhoods).

The evidence for the existence of food-deserts in the UK, Canada, Australia and New Zealand is ‘weak’ (Beaulac et al., 2009, p1). In contrast to the findings in the US, areas with higher ethnic minority concentrations in the UK tended to have greater access to supermarkets (Molaodi et al., 2011b). In Glasgow there was no clear pattern between supermarket location and neighbourhood deprivation (Macintyre, 2008). Furthermore, other UK-based studies found no differences by neighbourhood deprivation in food price, food availability, or access to supermarkets. In addition, low-income individuals in these studies did not report any difficulties in accessing supermarkets (Cummins and Macintyre, 2006). In contrast to the food deserts in the US, the term 'food prairie' has been proposed to describe low-income areas in the UK with many stores selling unhealthy foods which are open long hours i.e. 'an environment that predisposes to the grazing habit' (Hackett et al., 2008, p436).

Obesogenic environments are thought to result in an energy-dense diet through limiting access to healthy foods and facilitating access to unhealthy foods. However there is mixed evidence on the impact of the food environment on diet in adults. For example, while some have shown supermarket access to be associated with higher fruit and vegetable intake and better quality diets (Moore et al., 2008, e.g. Morland et al., 2002), others have found no association (e.g. Zenk et al., 2009). In Glasgow few associations were found between proximity to food stores (general stores, supermarkets or fruit and vegetable shops) and diet (high fat snacks, fruit and vegetable consumption) or BMI, even when individual characteristics such as gender, car ownership, and employment status were considered (Macdonald et al., 2011). Countries differ in their patterns of urban housing and retail markets and this likely contributes to the mixed results; findings from one context should not be extrapolated to another (Macdonald et al., 2011).

Improving the provision of healthy food in an area does not necessarily improve diet. Two UK-based studies which assessed the impact of a new supermarket opening in deprived neighbourhoods in Glasgow and Leeds found no improvements in diet (Cummins et al., 2005a, Wrigley et al., 2004). Proximity and convenience were cited as advantages of the new stores, but residents in Glasgow expressed concern that they might be tempted to spend more than they could afford and to overspend on luxury items. Therefore residents did not necessarily use the savings associated with having access to cheaper food to buy greater amounts of healthier foods. In Leeds, those who did not switch to the new store cited reasons including liking the familiarity of the old store, and having loyalty to the owners of neighbourhood convenience stores. Smaller stores often play a key role within a community and the presence of a supermarket can have a detrimental effect on them (Walker et al., 2010).

The relationship between food availability and food consumption is therefore complex. Studies to date have generally not considered how factors such as personal preferences, perceptions of different types of food, knowledge of healthy eating, or cultural norms and how they interact with availability (Walker et al., 2010). Furthermore social boundaries could be as important as physical ones in determining food accessibility. In the studies assessing the impact of the new supermarkets, some residents felt the new shops were for more affluent people and 'not for them', and some people travelled several miles to shop in areas which were 'physically distant (but) socially proximate' because they had grown up and lived there previously (Cummins, 2007, p196).

Parents are likely to be important mediators in the association between neighbourhood food availability and children and adolescents' dietary intake. This is likely to be particularly true for younger children and for food consumed in the home. Older children and adolescents will have more opportunities to buy food, for example snacks and lunch on school days. Compared to adults, adolescents too young to drive could be relatively restricted to places they can easily walk to, and hence the foods available in the areas close to their homes and schools could be important determinants of their diet. The majority of food bought by young people is probably for immediate consumption and hence they may be more inclined to buy what is easily available. It has been proposed that for young people, neighbourhood access is more likely to affect diet via easy availability to unhealthy food rather than easy access to healthy food which they may not want to eat anyway (Hackett et al., 2008).

Several US-based studies and one New Zealand study have characterised the food environments surrounding schools. Many schools have a fast-food restaurant within close proximity: in New York 25% of schools had a fast-food restaurant within 400m (Kwate and Loh, 2010); in Los Angeles County 23% of schools had at least one within 400m and 65% of schools within 800m (Simon et al., 2008); in Chicago 78% of schools had at least one fast-food outlet within 800m and the median distance from a school to an outlet was 0.5km (Bryn Austin et al., 2005); and a nationally representative US study which examined over 31,000 schools found that one third had a fast-food outlet within walking distance (0.5 miles) (Zenk and Powell, 2008). A Los Angeles study found over 60 fast food restaurants within walking distance of the school compared to only four stores which sold fresh fruit (Kipke et al., 2007). In New Zealand, 52% of primary schools had at least one fast food or convenience store within 400m, and 81% within 800m. The equivalent figures for secondary schools were 35% and 83% (Day and Pearce, 2011).

There is evidence that the likelihood of a school having a fast-food restaurant nearby differs by school type: high schools were more likely to have one near them than schools for younger children (Day and Pearce, 2011, Kwate and Loh, 2010, Simon et al., 2008, Sturm, 2008); smaller schools more likely than larger schools (Sturm, 2008); and state schools more likely than private schools (Kwate and Loh, 2010). Schools located in more deprived areas were more likely to have fast-food outlets and convenience stores near them (Day and Pearce, 2011, Simon et al., 2008, Zenk and Powell, 2008) as were those in more urban areas (Day and Pearce, 2011, Sturm, 2008), and those in commercially zoned areas (Day and Pearce, 2011). In New York, schools with high proportions of Black pupils, or in areas with high densities of Black residents, had more fast food outlets near them than schools in more White areas (Kwate and Loh, 2010). Furthermore, a US-wide survey of over 31,000 schools found that Hispanic pupils were more likely to attend schools with convenience stores, restaurants, snack stores and off-licences nearby (independent of neighbourhood deprivation or urbanicity) (Sturm, 2008).

Fast-food restaurants appear to specifically target areas near schools. Across the US, urban neighbourhoods with a school were more likely to have a fast-food outlet than those without a school (Zenk and Powell, 2008). Furthermore, in Chicago fast-food outlets cluster around schools; there are 3 - 4 times more fast-food restaurants within 1.5km of a school than would be expected if the restaurants were spread throughout the city unrelated to school location (Bryn Austin et al., 2005). Similarly, in New Zealand there were 5.5 times more fast food/convenience stores around schools than would be expected if there was no clustering (Day and Pearce, 2011).

The evidence base for neighbourhood effects on young people's diet is considerably more limited than that for physical activity. The evidence to date for each type of neighbourhood food source influencing children and adolescent's diet is discussed in turn, and then neighbourhood deprivation, ethnic density and urbanisation are considered. All of the studies summarised here adjusted for family-level SES unless otherwise stated and all were cross-sectional.

Fast food outlets

Having fast food outlets close to home was not associated with greater consumption of fast food, but was associated with lower fruit and vegetable consumption, in a study of children aged 5-6yrs and 10-12yrs in Victoria, Australia (Timperio et al., 2008, Timperio et al., 2009). A small study of boys in Texas found those who lived near a fast food restaurant ate more 'high fat vegetables' (chips, coleslaw and potato salad), but also more fruit and fruit juice (Jago et al., 2007). Greater distance to, and lower density of, fast food outlets was associated with lower sugar-sweetened beverage consumption in a sample of adolescents in Minnesota (Laska et al., 2010).

Convenience stores

Living closer to a convenience store was associated with a significant but small increase in consumption of crisps, chocolate, and white bread independent of neighbourhood deprivation in a study of children aged 9-10yrs in Norfolk, England (Skidmore et al., 2010). Boys in Texas found who lived further from a convenience store had higher intake of fruit, vegetables, and fruit juice (Jago et al., 2007). Similarly, children in Victoria, Australia who had convenience stores in their neighbourhood had lower vegetable consumption than those who did not (Timperio et al., 2008).

Supermarkets

In the Australian study, vegetable consumption increased as distance to the nearest supermarket increased (Timperio et al., 2008). Similarly, living further from a supermarket was generally associated with a healthier diet (more fruit and vegetables, less white bread) in children in Norfolk; however, in something of a contradiction, having more supermarkets within 800m of home was associated with a greater intake of both vegetables and unhealthy foods (Skidmore et al., 2010). A greater number of supermarkets in a 10 square mile radius from postcode was associated with slightly greater vegetable consumption in poor adolescents only in a US-based study; however the area used in this study is considerably greater than that in any of the others and arguably too large to be deemed a 'neighbourhood' (Powell and Han, 2011).

Deprivation

A US nationally representative survey of 8165 12-21yr olds found that greater neighbourhood (census tract) deprivation was associated with a greater likelihood of having an unhealthy diet; this finding held for all of the neighbourhood measures of deprivation considered (median family income, % poverty, % low education, median housing value, % blue collar workers) (Lee and Cubbin, 2002). This finding was independent of individual SES and ethnicity. This study also considered neighbourhood disorganisation characteristics which included: population turnover, % poor families headed by lone female, % unemployment, and % divorced. Greater population turnover and a higher proportion of poor families headed by a female were associated with a less healthy diet. Associations were generally stronger for girls than for boys, and in analysis stratified by age, associations remained significant for those aged 12-14yrs and 18-21yrs but not 15-17yrs.

In a study of 182 7-12yr olds in Alabama, total calorie intake did not differ by census tract deprivation level but the composition of the calories did; those in more disadvantaged neighbourhoods consumed a greater proportion of their calories from fat and trans-fat, and had a higher sodium intake (Keita et al., 2009). A London-based study of 11-12 year olds found that greater neighbourhood (LSOA) deprivation was associated with a greater intake of high-fat foods for both boys and girls, and lower fruit and vegetable consumption for girls (Wardle et al., 2003). However neighbourhood deprivation was considered a proxy of family-level deprivation in this study; it was therefore not possible to determine if neighbourhood deprivation had an effect on diet over and above family-level SES. Similarly, a New Zealand study found greater neighbourhood level deprivation to be associated with a lower likelihood of eating breakfast or lunch, and greater consumption of fast food, chocolates, crisps and soft drinks; however again there was no adjustment for individual deprivation in this study (Utter et al., 2011). Neighbourhood deprivation was not associated with nutrient intake (e.g. total energy, fat, sugars, protein) in a sample of 16-20yr old students in Newcastle, UK; again there was no adjustment for individual level deprivation (Lake et al., 2009).

Ethnic Density

Compared to adolescents (12-21yrs) living in neighbourhoods with the lowest density of Hispanics (quartile 1: 0-0.5%), those living in quartile 3 (1.7-6.7%) and quartile 4 (6.7% to

98.0%) were significantly more likely to have a healthy diet independent of own ethnic density or SES (Lee and Cubbin, 2002). This was the only study indentified which assessed the impact of neighbourhood level characteristics on ethnic differences in diet; after adjustment for Hispanic ethnic density, the Hispanic adolescents were no longer significantly more likely to have a healthy diet than their non-Hispanic White peers. Black ethnic density was not associated with the likelihood of having a healthy diet; the Black adolescents had the unhealthiest diets and this remained after adjustment for individual and neighbourhood SES.

Urbanisation

A higher proportion of multi-unit housing (defined as more than 5 homes in one structure) in a neighbourhood was associated with a healthier diet in the US study of adolescents (Lee and Cubbin, 2002). This contradicts the findings of a Liverpool based study which visually assessed neighbourhoods where the children had the best and worst eating habits (Hackett et al., 2008). The area where the children with the healthiest diets lived was characterised by: low density housing; larger homes; wider streets; allotments; presence of trees, grass and flowers; space to play; and no shops of any kind. The area where the children had the poorest diets had: dense, small housing; narrow streets; no greenery; little space; heavy traffic on main road; and many shops including take-aways, convenience stores, a large supermarket and several mini-markets. Despite the differences between the areas, they were physically close and had very similar socio-economic profiles.

1.3.3 Neighbourhood effects on overweight/obesity

1.3.3.1 Findings from systematic reviews

The number of papers reporting neighbourhood effects on children and adolescents' body size has increased greatly in recent years and four systematic reviews have been published since 2008; two included studies which examined both social and physical/built environment characteristics (Black and Macinko, 2008, Carter and Dubois, 2010) and two only the built/physical environment (Dunton et al., 2009, Galvez et al., 2010). A further review which focused on US-based studies of disadvantaged groups was not included as child and adult results were combined (Lovasi et al., 2009). Several studies feature in more than one review. The majority were US-based, cross-sectional, and had obesity, overweight or BMI outcomes. Some used self (or parent) reported height and weight measures; this was more common in studies that used perceived rather than objective measures of neighbourhood characteristics. Neighbourhood characteristics found to be associated with child or adolescent body size are summarised in Table 1.2. Many results were mixed, particularly in the reviews featuring a greater number of studies i.e. for a given neighbourhood characteristic the studies found a mixture of positive, negative, or no association. There was often variation within studies (i.e. a neighbourhood characteristic might have been significant only for a particular subgroup e.g. girls, low SES, those in urban areas, or young children).

A neighbourhood characteristic for which there were (generally) consistent findings was neighbourhood deprivation; those in more deprived neighbourhoods were more likely to be overweight/obese. There was also some evidence that more green space/vegetation may be associated with lower overweight/obesity. Evidence of associations with food availability or physical activity facilities was mixed; this is likely due in part to differences between studies in terms of facilities examined (e.g. some studies included fast food outlets, others convenience stores) and in measures of availability (e.g. self-reported, objective measures of density, objective measures of distance). Due to the many mixed results, the reviews were generally cautious in their overall conclusions; for example Carter and Dubois state that 'heterogeneity and methodological issues across studies limits our ability to draw overall conclusions' (2010, p616) and Dunton et al. conclude that there were 'few consistent findings…for most environmental variables considered strong empirical evidence is not yet available' (2009, p393).

Table 1.2 Systematic reviews examining the association between residential neighbourhood characteristics and body size

Author, year, title	Databases searched	Period covered	Inclusion criteria	Exclusion criteria	No. papers	Key findings
Black & Macinko, 2008 Neighbourhoods and obesity	Pubmed Psychinfo	Up to March 2007	i. outcome measure included measure of body weight, physical activity or diet ii. included neighbourhood level measure iii. Human population in industrialised country iv. English language	None stated	10 with children or adolescents (36 in total review)	**General characteristics of studies included** 2 studies used multilevel analysis 6 studies used self-reported height and weight **Neighbourhood SES correlates of body size** Neighbourhood deprivation + **Neighbourhood Food availability correlates of body size** Higher fruit and vegetable prices + **Neighbourhood Physical Activity correlates of body size** Parent reported road safety (10-12yrs) – Parents' perceived neighbourhood safety - Mixed for PA facilities **Overall conclusions (based on all 36 studies)** 'Neighbourhood level services and structures…are emerging as important and potentially modifiable loci for public health intervention.'
Carter & Dubois, 2010 Neighbourhoods and child adiposity: a critical appraisal of the literature	Medline Embase PsychInfo Scopus	1999 to July 2009	i. examined features of the social and physical neighbourhood ii. an adiposity measure as a primary outcome ii. neighbourhood based on either child's residence or school location as a proxy iii. Subjects aged 2-18yrs iv. English or French	i. Large areas rather than neighbourhoods (e.g. cities, regions, whole countries) ii. studies aggregating adolescents with adults iii. sample size <100	27	**General characteristics of studies included** 16 US-based, 6 Canada, 2 Australia, 2 UK, 1 Germany 81% (n=22) cross-sectional 11 of the studies used MLM techniques. Height/weight not measured in 8 studies Neighbourhood based on school location in 3 studies Residential mobility addressed in design or analysis in 5 studies **Physical environment correlates of body size** Examined in 11 studies Neighbourhood vegetation/greenness – Mixed results for physical disorder (e.g. garbage, broken glass) /aesthetics Mixed results for PA facilities Mixed results for food retail establishments

			language			Mixed results for neighbourhood street design/walkability **Social environment correlates of body size** Examined in 21 studies Neighbourhood disadvantage + Social capital (e.g. collective efficacy) – **Cluster analysis (combining social and physical measures)** Living in rural, exurban, and mixed urban areas (compared to suburban and inner city areas) + **Overall conclusions** ‘Heterogeneity and methodological issues across studies limits our ability to draw overall conclusions.’
Dunton et al., 2009 Physical environmental correlates of childhood obesity: a systematic review	PubMed PsychInfo Geobase	Up to 31st May 2008	i. Features of built or biophysical environment ii. BMI, overweight or obesity outcome iii. quantitative iv. report results for youth (0-18yrs) v. English language	Papers only including social environment features (e.g. crime, safety, SES, population density) or those regarding only characteristics associated with food consumption (e.g. fast food outlets).	15	**General characteristics of studies included** 80% (n=12) published after 1st January 2006 7 on children (3.-12yrs), 7 on adolescents (13-18yrs), 1 both (3.-18yrs) 86% (n=13) cross-sectional Body size self-reported in 1 study **Significant correlates of body size in children** Hazards (litter, rubbish, noise) in low SES children - Vegetation (in high population density areas) – Intersection density (girls) – Parent reported road safety (10-12yrs) – Child-reported access to PA facilities – Heavy traffic (older children) + **Significant correlates of body size in adolescents** Equipment availability/PA facility access – Living in rural, exurban, or mixed urban areas (compared to suburban or inner city areas; based on cluster analysis) + **Overall conclusions** ‘Few consistent findings…for most environmental variables considered strong empirical evidence is not yet available.’

Galvez et al., 2010 Childhood obesity and the built environment	PubMed PsychInfo Web of Science CINAHL	Jan 2008 to Aug 2009	i. sample <18yrs ii. features of built environment (e.g. physical structures, walkability, safety) iii. Obesity or obesity related behaviour outcomes	i. articles only describing future studies ii.not relevant to developed countries iii. compared only urban/rural means iv. large scale geographies v. focus on neighbourhood SES, ethnic density, social environment	15 with obesity outcome (48 in total review)	**General characteristics of studies included** 6 measured distance to and/or density of food sources, PA facilities and ‘facilitators of active commuting’ (e.g. pavements, subway stations). 3 studies had ‘perceived access’ measures 8 studies examined aspects of neighbourhood safety (perceived and objective crime measures) **Significant correlates of body size** Density fast food restaurants (low SES only), short distance to fast food restaurants + Presence and density of convenience stores + Distance to playgrounds - Density of subway stations – Perceived access to gardens, playgrounds, parks, shops (children) and recreational facilities (children and adolescents) - Mixed results for physical disorder Mixed results for perceived safety (both parent and child) **Overall conclusions** ‘Novel research examining the built environment and childhood obesity continues to build….(but) further studies are needed in diverse populations that vary by key sociodemographics…..’

+ positive association with body size, - negative association with body size

1.3.3.2 Findings from recent studies

The systematic reviews include literature published up until July 2009 for the social environment (Carter and Dubois, 2010) and August 2009 for the built environment (Galvez et al., 2010). Ovid was used to search the Medline and Embase databases to identify recent studies (i.e. published since the systematic reviews) which had investigated the association between at least one neighbourhood characteristic (either social or physical/built) and body size in children or adolescents. Thirteen studies were identified; six based in the US, two each in Canada, Australia, and the UK, and one in Ireland. Three had a longitudinal design and height and weight were measured in all but one of the studies. The study outcomes were all BMI/overweight/obesity except for one study which had percentage body fat (Dengel et al., 2009). Sample ethnicity was reported in four of the studies (all US-based), including one which included only Latino children. In order to summarise the recent findings in these 13 papers, I have grouped the neighbourhood characteristics into broad categories (physical activity facilities; walkability; crime/safety; food sources; deprivation; ethnic density; green space; public transport and population density) and these are discussed in turn. An overall summary is provided in Table 1.3.

Neighbourhood physical activity facilities

Six of the studies included a neighbourhood physical activity (PA) facilities measure. Three used perceived measures (Davidson et al., 2010, Edwards et al., 2009, Nelson and Woods, 2009), two used objective measures (Dengel et al., 2009, Timperio et al., 2010) and one used both (Crawford et al., 2010). Three of the four studies with perceived measures, and one of the three studies with objective measures, found a significant association between perceived physical activity facilities in the neighbourhood and body size.

In the study by Davidson et al. (2010), children of parents who perceived that there were good playgrounds/parks/sidewalks in their neighbourhood had significantly lower BMIs than those whose parents did not (this study grouped sidewalks with parks rather than walkability factors as is done in most other studies) independent of individual SES. In a study of adolescents, those who were overweight or obese reported significantly fewer PA facilities within 5-10mins walk from their home, or on a frequently travelled route (e.g. somewhere they passed on way home from school). Furthermore, the perceived number of PA facilities was negatively associated with overweight/obesity, and the only variable to remain significant, in fully adjusted models (adjusting for sex, age, population density, parental occupation and other neighbourhood characteristics) (Nelson and Woods, 2009). This study also considered physical activity as a covariate and found that it did not 'directly influence or mediate the relationship between perceived facilities and weight status' (p917).

The study by Edwards et al. (2009) was unusual in that the neighbourhood perceptions were those of respondents in a separate study (Health Survey for England 2002); their responses were aggregated and linked to each child's data at the LSOA level. In this study 'good access to leisure facilities' (as perceived by the HSE respondents) was associated with lower levels of obesity regardless of the affluence of the area. This study included two age groups however the sample size was not adequate to test whether the findings differed by age. An important limitation of this study is that it does not appear that any individual-level covariates were adjusted for. One study with perceived measures did not find a significant association; parental perception of availability of sporting venues in the local area was not significantly related to change in BMI SDS (it is unclear which covariates were adjusted for) (Crawford et al., 2010).

Timperio et al. (2010) used both 800m and 2km buffers around the children's homes to calculate the density of sport/recreation spaces with no fees or restricted opening hours; the number of sports options for children; the existence of gyms/leisure centres or swimming pools; the length of walking/cycling tracks; and the distance to school. The authors chose the 800m buffer as parents reported that was the walking distance of the younger children (5-6yrs at baseline); the larger 2km buffer size was selected because walking distance increases as children grow older and 'the scale of neighbourhoods can be further extended via vehicle use' (p3). In cross-sectional analysis, the number of sports/recreation public open spaces within 800m was inversely related to BMI in the 10-12yr olds but not the 5-6yr olds. In the longitudinal analysis (change in BMI SDS over 3yrs as outcome) none of these neighbourhood variables was significant.

The Crawford et al. (2010) study used data from the same study as Timperio (2010) but included only the older children (10-12yrs at baseline) and three waves of data rather than the two in the Timperio study. The objective measures are as described for the Timperio study, except that only the 2km buffer was used; none of the measures were significantly related to BMI SDS over 5 years. Dengel et al. (2009) calculated the distance from each child's home to the nearest park, gym, recreation centre, walking/biking trail, and to school. There was no significant association between distance to these facilities and % body fat in models adjusted for age, sex and pubertal status or in models stratified by sex.

Neighbourhood walkability/road safety

The definitions of 'walkability' differed by study; I have taken walkability to include any items related to: the presence of sidewalks/pavements; the layout/density/type of roads; traffic/road/pedestrian safety; and street lighting. Studies solely examining overall safety/crime are not included here as they are summarised in a later section; however it is acknowledged that general crime levels may be an important component of walkability.

Six studies examined walkability. Three used perceived measures (Davidson et al., 2010, Elder et al., 2010, Nelson and Woods, 2009), two used objective measures (Dengel et al., 2009, Timperio et al., 2010) and one used both (Crawford et al., 2010). Two studies reported significant associations (one perceived and one objective). The study with perceived measures which found a significant association combined parental reports of the existence of sidewalks on most streets with existence of good playgrounds/parks (Davidson et al., 2010). This variable had a negative association with BMI (i.e. the more sidewalks/playgrounds/parks the lower the BMI); however it is not possible to know whether it was the sidewalks (which are arguably directly related to neighbourhood walkability) or playgrounds/parks (which are perhaps more 'destinations') or both which are driving this negative association.

In the one study which included adolescent's perceptions of walkability, overweight/obese adolescents were more likely to report poorer pedestrian safety in their neighbourhoods however there were no differences in the other walkability characteristics (e.g. street connectivity, street lighting, presence of hills) by weight status. Furthermore, in fully adjusted models none of the walkability characteristics were associated with overweight/obesity (Nelson and Woods, 2009). Two studies found no association between parental perceptions of walkability and their child's BMI SDS (Crawford et al., 2010, Elder et al., 2010). In the study of Latino children from relatively deprived families, neighbourhood walkability was the last variable to be added to a model which already included many potential confounders (child characteristics; home characteristics; parental characteristics; and school characteristics) (Elder et al., 2010). Objective measures of road connectivity (cul-de-sacs, intersection density, total length of access paths) and traffic exposure (total length of busy roads) were included in the Australian studies (Crawford et al., 2010, Timperio et al., 2010). In the Timperio et al. (2010) study, in cross-sectional analysis more access paths were associated with lower BMI SD scores for both younger (800m and 2km buffer) and older children (800m buffer only). The length of local roads in 2km buffer was also negatively related to BMI SDS for older children. In longitudinal analysis (change in BMI SDS over 3yrs), the number of 4-way intersections was negatively associated with change in BMI SDS for younger children (800m buffer). A greater length of access paths was associated with a greater increase in BMI SDS in older children (800m buffer). In the Crawford et al. (2010) study none of these measures were related to BMI SDS. A study with objective measures of street patterns, pedestrian infrastructure, and distance to and density of transit neighbourhood (all within 1600m buffer) found none to be associated with % body fat (Dengel et al., 2009).

Neighbourhood crime/safety/disorder

Six studies examined the impact of neighbourhood safety on body size; all used perceived measures. Three of the studies found significant results. In the study by Bacha et al. (2010), mothers reported their perceptions of neighbourhood safety when their children were in 3rd Grade (8-9yrs), then the height and weight of the children was measured in 5th Grade (10-11yrs). Girls, but not boys, living in the least safe tertile in 3rd Grade were significantly more likely to be obese and to have higher mean BMI SD scores in 5th Grade than children in the safest tertile (after adjustment for sex, race and household SES). Time spent outdoors, television watching, and pubertal status did not explain these significant relationships between perceived safety and body size. The Davidson study (2010) also included 5th graders and parents safety perceptions; children living in areas perceived to be safer had significantly lower BMIs than those in less safe areas. Edwards et al. (2009) only included one neighbourhood safety item (from HSE 2002); 'perception of problem with teenagers hanging around'. This variable was positively associated with child obesity in the most affluent census ward in the study but not in the medium or low SES wards.

Adolescents who rarely or never felt safe in their neighbourhoods were more likely to be overweight or at risk of overweight but results were not statistically significant in fully adjusted models (controlling for ethnicity, school grade, and clustering by school) (Duncan et al., 2009). Those who said they never or rarely felt safe in their neighbourhoods were more likely to have reported the presence of gang violence and to have seen someone attacked with a weapon. In a further study of adolescents, personal safety (streets well lit at night; crime rate) and aesthetics (litter; trees along the streets) were not associated with overweight/obesity in models adjusted for age, sex, SES and clustering by school (Nelson and Woods, 2009). Similarly, no significant association with BMI SDS were found for the safety measure used by Elder et al. (2010) (already described in the previous section on walkability as it is an aggregate of items on perception of crime and lights and vehicle exhaust).

Neighbourhood food outlets

Five studies investigated whether the presence of food outlets in the neighbourhood was associated with body size. The type of food outlets assessed varied between studies. One out of the two perceived studies, and one out of the three objective studies, found a significant result. In one study, perceived access to supermarkets (from HSE 2002) had a strong negative association with BMI SDS independent of the ward deprivation level Edwards et al. (2009). However in the other study to use perceived measures, parents' perceived access to stores to purchase vegetables and fruits was combined with two other measures ('like my neighbourhood' and 'access to sport/recreation programs') to make an overall neighbourhood satisfaction variable; this was not associated with BMI SDS (Davidson et al., 2010).

Children living in deprived areas of Leeds (a multi-ethnic UK city) had more fast food outlets in their neighbourhoods than children in more affluent areas, and the distance from the home to the nearest fast food outlet was shorter for those in deprived areas. In models adjusted for age, sex, and neighbourhood deprivation the density of fast food outlets in an area was positively associated with overweight/obesity but not with BMI SDS. Proximity to nearest fast food outlet was not associated with either overweight/obesity or BMI SDS (Fraser and Edwards, 2010). In a US study of young children (5-8yrs), neither the number of restaurants or grocery stores within a 1-mile radius of the school was significantly related to BMI SDS (Elder et al., 2010) (this study used school neighbourhood as a proxy for residential neighbourhood).

Dengel et al. (2009) report a significant negative association between the distance to the nearest fast food outlet and % body fat, and a significant positive association between % body fat and the density of both small and large grocery stores within 1600m (20min walk) of the home in unadjusted analysis. However after adjustment for age, sex and pubertal status there were no significant associations. It was not possible to determine which of these factors explained the association as adjusted models were not presented.

Neighbourhood green space

Two studies, both using objective measures, examined the relationship between green space and body size. No significant results were found. In one study, percent land use for ‘parks and recreation’ within 1600m (20min walk) of home, and distance from home to park, were unrelated to % body fat (Dengel et al., 2009). In the second study, four measures of green space were examined: the number of parks/green space per 10,000 residents in an area; the proportion of land in an area which was parks/green space; mean distance to nearest park/green space in each community; proportion of each area within walking distance (800m) of park/green space. No significant associations with overweight/obesity were found for any of these measures in analysis controlled for age, sex, neighbourhood deprivation and ethnic density (Potestio et al., 2009).

Neighbourhood land use - other

Land-use ‘other’ refers to neighbourhood land use which is not otherwise covered in other sections (such as green space, road networks, food outlets). The study by Dengel et al. (2009) explored the proportion of land use within a 1600m buffer which was residential, and the proportion which was vacant. Neither was associated with % body fat.

Neighbourhood Ethnic density

Two studies (both US) investigated the impact of neighbourhood ethnic density on body size. Non-White ethnic density was positively associated with obesity levels in analysis adjusted for age, sex and individual SES (health plan) and spatial clustering; however this relationship was completely attenuated by further adjustment for neighbourhood deprivation (Grow et al., 2010). Similarly, ‘% visible minority’ in a neighbourhood had no significant association with overweight/obesity in models adjusted for sex and neighbourhood deprivation (Potestio et al., 2009). A weakness of both these studies is that individual level measures of ethnicity were not included.

Neighbourhood deprivation

The association between neighbourhood deprivation and body size was examined in four studies (2 US, one UK, one Canada); three found deprivation to be positively associated with overweight/obesity. In the Canadian study, neighbourhood deprivation was measured by community education level (% with Bachelor’s degree). Children in less educated areas had higher the rates of overweight/obesity independent of family-income (which was also a significant correlate) and % visible minority in the neighbourhood (Potestio et al., 2009).

Similarly, in Leeds neighbourhood deprivation (Index of Multiple Deprivation at LSOA level) was significantly associated with overweight/obesity (but not with BMI SDS) in models adjusted for age, sex, and density of fast food outlets in the neighbourhood. When 'distance to' rather than 'density of' fast food outlets was included in the models, the association between neighbourhood deprivation and obesity remained significant but not the association with overweight including obesity (Fraser and Edwards, 2010).

Furthermore, in a US study all four measures of census tract deprivation (median household income, % home ownership, % females with ≤ high school education, % single parent household) were significantly associated with obesity when analysed independently in models adjusted for age, sex and SES (health plan). For each variable, more deprivation was associated with higher levels of obesity. When entered into a model together, along with % non-White, only median income and home ownership remained significant. However in this model a decrease in home ownership was associated with lower obesity levels (i.e. the opposite direction of relationship to that seen in the univariate analysis) (Grow et al., 2010).

In contrast, another US study did not find an association between neighbourhood SES and BMI (Voorhees et al., 2009). This study, which included only girls, measured neighbourhood SES by the Townsend Index (based on % employed, % owner occupation, mean number persons per household, and % households with no vehicle). Neighbourhood was defined by a 0.5 mile buffer around the home, and measures of individual SES (highest parental education, whether the child was in receipt of a free school lunch) and school SES (% in school receiving free lunch) were adjusted for. None of the SES measures (individual, neighbourhood or school) were significantly related to BMI. Ethnicity was significant independent of the SES measures; Blacks and Hispanics had higher BMIs than Whites. This was one of only two studies included in this review of recent papers which presented any results stratified by ethnicity/ethnic-specific effects sizes (the other being the Duncan (2009) study).

Public transport

Two studies included perceived measures of public transport. There was no association between BMI SDS and parental reports of whether 'public transport is limited in my area' (Crawford et al., 2010). Similarly, in the study which used neighbourhood perceptions from the HSE 2002, 'quality of public transport links' was unrelated to children's obesity levels (Edwards et al., 2009).

Population Density

Four studies included a measure of population density. Two studies classified areas based on population (e.g. urban, town, rural); Davidson (2010) found that those in towns and rural areas had higher BMIs than those in urban areas (although detailed results are not reported). However, Nelson and Woods (2009) found no relationship between area type and overweight/obesity. An alternative density measure, population per unit land area in a 1600m buffer of each home was unrelated to % body fat (Dengel et al., 2009). Similarly, number of households per acre was unrelated to obesity (Grow et al., 2010). Overall there was little evidence of an association between population density and body size.

School neighbourhoods

Young people who walk or use public transport to get to school, and those who leave their school grounds at lunchtime, will spend time in the neighbourhood surrounding their school. School neighbourhoods could impact on obesogenic behaviours through encouraging unhealthy diets or discouraging active transport. Five studies examined the association between school neighbourhoods and body size; one UK-based (Drummer et al., 2005), one US-based (Powell et al., 2007), and three Canadian (Janssen et al., 2006, Merchant et al., 2007, Seliske et al., 2009) (of which the Seliske and Janssen papers used data from same study). Only Seliske (2009) explicitly stated an interest in the effects of school neighbourhood on obesity. In the Merchant et al. (2007) study, which used perceived rather than objective measures, the neighbourhood and school neighbourhoods are conceptualised as being one in the same due to children living close to school. In the other studies, school neighbourhood is a proxy of residential neighbourhood (perhaps due to individual postcodes not being available). A sixth study included neighbourhood characteristics at both the school and neighbourhood level (Sturm and Datar, 2005). However as results were almost the same the school results were not presented in the paper (this study is included in the systematic reviews described previously).

Two of the studies examined the food environment surrounding schools and body size. The Canadian study found that pupils with more food retailers in their environment actually had a lower risk of overweight/obesity than those with less food retailers; they concluded that 'limiting the number and type of food retailers within the school environment may not be an effective strategy for the prevention and reduction of overweight and obesity in youth' (Seliske et al., 2009). In contrast, the US-based study found a significant negative association between density of chain supermarkets and BMI/overweight status independent of the presence of other food outlets, food price indices, and area-level SES (Powell et al., 2007). Conversely, the density of convenience stores was positively associated with BMI and overweight although much of this association was explained by neighbourhood SES. This study stratified analysis by ethnicity and mother's work status; the association between supermarket density and BMI was substantially stronger for African Americans than Whites and Hispanics, and stronger for those whose mothers worked full-time compared to those whose mothers did not work.

Three studies investigated school neighbourhood deprivation and body size. The UK-based study found no association between electoral ward deprivation (IMD) and overweight/obesity (Drummer et al., 2005). In contrast, a Canadian study found that school neighbourhood deprivation (as measured by unemployment rate) was significantly associated with obesity independent of family-level SES. However the other measures of area-level deprivation in this study (education levels and income) were not associated with obesity. This study used a relatively large 5k buffer around schools; however they report that analysis was also conducted with a 1k buffer and results were the same (Janssen et al., 2006). In another Canadian study, the two schools were located in areas which differed in perceived walkability and deprivation but mean BMI was similar in both schools (Merchant et al., 2007). The children attending the more deprived, less walkable school ate more junk food but they were also more active; the authors conclude 'the factors contributing to body weight of children in these two schools were likely different'.

Table 1.3 New papers (published since systematic reviews) of neighbourhood associations with children and adolescents' body size

	Papers reporting association with a body size measure[1]	Papers reporting no association[1]
Physical Activity Facilities	Measured: Timperio (2010): 10-12yrs, BMI, Australia. Perceived (child): Nelson (2009): 15-17yrs, overweight/obese, Ireland. Perceived (parent): Davidson (2010): 10-11yrs, BMI, Canada Perceived (adults in separate study): Edwards (2009): 3-15yrs, obesity, UK	Measured: Crawford (2010): 10-12yrs, Australia. Dengel (2009): 10-16yrs, % body fat, USA Timperio (2010): 5-6yrs, BMI, Australia. Perceived (parent): Crawford (2010): 10-12yrs, Australia.
Food environment	Measured: Fraser (2010): 3-14yrs, overweight/obesity, UK Perceived (adults in separate study): Edwards (2009): 3-15yrs, obesity, UK	Measured: Dengel (2009): 10-16yrs, % body fat, USA Elder (2010):3-8yrs, BMI, USA. Fraser (2010): 3-14yrs, BMI, UK Perceived (parent): Davidson (2010): 10-11yrs, BMI, Canada
Ethnic density		Measured: Grow (2010): 6-18yrs, obesity, USA Potestio (2009): 3-8yrs, overweight/obese, Canada
SES	Measured: Fraser (2010): 3-14yrs, overweight, UK Grow (2010): 6-18yrs, obesity, USA Potestio (2009): 3-8yrs, overweight/obese, Canada	Measured: Voorhees (2009): 11-12yrs, girls, BMI, USA.
Walkability	Measured: Timperio (2010): 5-6yrs & 10-12yrs, BMI, Australia. Perceived (parent): Davidson (2010): 10-11yrs, BMI, Canada	Measured: Crawford (2010): 10-12yrs, Australia. Dengel (2009): 10-16yrs, % body fat, USA Perceived (child): Nelson (2009): 15-17yrs, overweight/obese, Ireland. Perceived (parent): Crawford (2010): 10-12yrs, Australia. Elder (2010):3-8yrs, BMI, USA.
Safety	Perceived (parent): Bacha (2010): Girls, 10-11yrs, USA Davidson (2010): 10-11yrs, BMI, Canada Perceived (child): Duncan (2009): Other ethnic group only; 14-18yrs; overweight, USA Perceived (adults in separate study): Edwards (2009): 3-15yrs, affluent area, obesity, UK	Perceived (parent): Bacha (2010): Boys, 10-11yrs, USA Crawford (2010): 10-12yrs, Australia. Elder (2010):3-8yrs, BMI, USA. Perceived (child): Duncan (2009): Overall sample and all ethnic groups except Other; 14-18yrs; overweight, USA Nelson (2009): 15-17yrs, overweight/obese, Ireland. Perceived (adults in separate study): Edwards (2009): 3-15yrs, low and middle income areas, obesity, UK
Green space/Parks		Measured: Dengel (2009): 10-16yrs, % body fat, USA Potestio (2009): 3-8yrs, overweight/obese, Canada

Land Use Other		Measured: Dengel (2009): 10-16yrs, % body fat, USA
Public transport		Perceived (parent): Crawford (2010): 10-12yrs, Australia. Perceived (adults in separate study): Edwards (2009): 3-15yrs, low and middle income areas, obesity, UK
Population Density	Measured: Davidson (2010): 10-11yrs, BMI, Canada	Measured: Dengel (2009): 10-16yrs, % body fat, USA Grow (2010): 6-18yrs, obesity, USA Nelson (2009): 15-17yrs, overweight/obese, Ireland.

[1]Findings referred to fully adjusted models unless no adjustment was made

1.3.4 School effects on physical activity, diet and overweight/obesity

One of the mechanisms through which neighbourhoods could influence adolescent behaviour is via schools. Schools are a dominant feature in the lives of young people (Leventhal and Brooks-Gunn 2000); over a quarter of waking hours are spent at school over the course of a year (Richmond et al., 2006) and children have more ‘continuous and intensive’ exposure to school environments than any other neighbourhood institution during the first two decades of their life (Leventhal and Brooks-Gunn, 2000, Story et al., 2009). ‘Resources available to or cultural norms within schools may constitute critical mechanisms through which schools impact the BMI of their students’ (Richmond et al., 2006).

The quality, ethos, and demographics of a school are often strongly determined by the characteristics of the neighbourhood in which they are situated (Leventhal and Brooks-Gunn, 2000). However the school environment can buffer negative neighbourhood influences (Richmond et al., 2006). Although many studies of diet, activity and body size in young people have recruited their samples via schools, few have examined characteristics of schools themselves (such as the physical, socio-cultural, or economic environment) (Ferreira et al., 2006, Richmond et al., 2006).

1.3.4.1 Physical Activity

Schools can increase energy expenditure by promoting physical activity (Story et al., 2006). Equipment and facilities for activity, well-designed and implemented activity programs, and teacher supervised activities in breaks, have all been linked with improved physical activity levels in pupils (Davison and Lawson, 2006, Ferreira et al., 2006, Sallis et al., 2001). The social environment is also of importance. Studies have found an enjoyment of school to be positively associated with activity levels (Limstrand, 2008). Children in an Australian study who felt supported by their teachers (‘encouraged to express views; treat us fairly’) and peers (‘pupils enjoy being together; most pupils are kind; they accept me as I am’) were more active than those who did not (McLellan et al., 1999). Social norms may facilitate or discourage activity during intervals and lunch time. In the US, studies of school type found activity to be higher in high schools compared to vocational schools (Ferreira et al., 2006).

One study assessed whether school ethnic density (% non White) or median family income of pupils in the school could explain ethnic differences in physical activity in adolescence using data from a large US-based study of 17,000 adolescents (Richmond et al., 2006). Schools were racially segregated; more than three quarters of the Black and Hispanic pupils were in a school where <67% of the pupils were White, and almost 40% of the White pupils attended a school where >94% of the pupils were White. The median household income was markedly lower in the schools attended by the Hispanic and Black adolescents compared to their White peers. The variance in PA due to differences between schools was significant; 8.3% (95% CI: 6.2% to 11.0%) for girls and 5.6% (4.0% to 7.6%) for boys. School level median income was positively associated with activity levels for both boys and girls; however a higher proportion of White pupils in a school was associated with more activity for boys but not girls (models adjusted for individual characteristics and family SES). For girls, the lower activity levels of Blacks and Hispanics compared to their White peers could be accounted for by the schools they attended. For boys, both Blacks and Hispanics were more active than Whites after controlling for between school variation.

1.3.4.2 Diet

School food environments can have a substantial impact on diet; in the US 19-50% of total daily calories are consumed at school, and vending machines, school stores, canteens or snack bars are present in 89% of high schools (Story et al., 2009). These often sell sugary drinks and high-fat, salty snacks with only 18% of the total food they sell being fruit or vegetables (Story et al., 2006). Vending machines are associated with more snacking and lower fruit consumption, and a la carte menus with increased saturated fat intake (Kubik et al., 2003, Neumark-Sztainer et al., 2005) and having regular sugar/fat items available in the school was negatively associated with fruit intake (Terry-McElrath et al., 2009). However associations between availability and consumption are not always in the expected direction. A Danish study found pupils in schools with fruit/vegetables available but no unhealthy snacks had *lower* fruit and vegetable intake than pupils in schools with no fruit/vegetables or unhealthy snacks available, or schools with both fruit/vegetables and unhealthy snacks (Krolner et al., 2009). The food environment surrounding school may also be important; in the US soft drink consumption was higher in pupils who attended schools with more small food stores close to their school (van der Horst et al., 2008). Students in US schools with a ‘closed campus’ lunchtime policy are less likely to buy lunch at fast food outlets or convenience stores compared to those whose schools allow them to leave school grounds (Neumark-Sztainer et al., 2005). Social norms and the social environment of the schools can influence diet. Pupils who thought their friends consumed a lot of snacks were more likely to do so themselves, as were those who had a positive attitude towards snacking (van der Horst et al., 2008). Perceptions of peers' body size could also contribute to weight-related behaviours (Perkins et al., 2010). Pupils who reported that their teachers were very unsupportive were more likely to eat fast food ≥4 times a week than those who had supportive teachers independent of pocket money and peer and school environment measures (McLellan et al., 1999).

1.3.4.3 Overweight and obesity

Few studies have examined school effects on body size measures. A Leeds based study found that some schools had a 'beneficial' effect and others a 'detrimental' one on primary pupils' BMIs, but no specific school characteristics were examined (Procter et al., 2008). Three US studies used nationally representative data to investigate the association between school characteristics and BMI and/or obesity. Few associations were found between school PE policies, or the proportion of pupils actively commuting, and student levels of overweight (O'Malley et al., 2009). Similarly, there was little association between school food environments and a school's overweight and obesity levels (Terry-McElrath et al., 2009). In one US study school SES (measured by average parental education) remained a significant correlate of body size after adjustment for individual characteristics but school ethnic density did not; schools with a higher proportion of children from low SES families had higher proportions of overweight pupils (O'Malley et al., 2007). In this study pupils in state schools had higher BMIs than those in private schools but this association was insignificant after adjustment for school SES and other school characteristics. A further US study found that pupils in state schools had higher BMIs than those in private schools, with the difference being larger for those from low SES families. Furthermore, pupils from higher SES families were more likely to be overweight if they attended a state school but for low SES pupils overweight levels did not differ by school type (Li and Hooker, 2010).

Two studies were identified which assessed the impact of school characteristics on ethnic differences in body size in adolescence (Bernell et al., 2009, Richmond and Subramanian, 2008). The study by Richmond and colleagues used the same large sample of 17000 adolescents as previously described for the physical activity paper (Richmond et al., 2006). Compared to the variance between schools in PA levels, between school variance for BMI was lower: 4.8% (95% CI 3.4% to 6.5%) for girls and 3.5% (2.4% to 4.9%) for boys. A higher mean household income was associated with lower mean BMI for both boys and girls. School ethnic density was not associated with BMI. In the final models, the Black and Hispanic girls and the Hispanic boys still had significantly higher BMIs than their White peers however differences were attenuated. In this study few schools were sampled per community and so it was not possible to distinguish between school and community effects. The authors acknowledged this; 'it is reasonable to speculate that the schools might also be acting as a proxy for the community…however it is equally likely that the schools may influence the health behaviours and outcomes of their students independent of the community in which the student lives' (Richmond et al., 2006, p2164).

The Bernell study also examined school ethnic density and association with BMI for Black and Hispanic girls only; Black and Hispanic girls had higher BMIs than their White peers if they attended a school with a low proportion of White pupils (<50%) but not if they attended a school where over half the pupils were White (Bernell et al., 2009). Additionally, Black and Hispanic girls in mainly White schools had lower BMIs than Black and Hispanic girls in mainly non-White schools. This was independent of a range of individual and family characteristics including household income, family type, and parental BMI. These patterns were not observed for boys.

1.4 Aims and thesis outline

There is a sparsity of UK literature on when in the lifecourse ethnic differences in body size emerge and on the determinants of these ethnic differences. Studies to date have been limited by aggregated ethnic group categories and cross-sectional designs. Although the potential importance of neighbourhoods and schools in promoting or discouraging obesogenic behaviours has been recognised in recent years, findings for contextual effects on body size in young people have been equivocal. Methodological and sample differences between studies makes drawing firm conclusions difficult, and few studies have considered a range of characteristics or both school and neighbourhood environments. The majority of studies to date have been US based. Few UK studies have examined whether characteristics of school or neighbourhood environments are related to obesity in adolescence and none have considered whether they could explain ethnic differences in obesity.

This thesis therefore aims to add to the existing literature by determining whether school or neighbourhood contexts can explain ethnic differences in body size in adolescence in the UK. It is hypothesised that ethnic differences in where adolescents live or the schools they attend may contribute to ethnic differences in body size in adolescence, independent of individual or family characteristics. To date no UK studies have tested this hypothesis. To address this aim this thesis uses data from DASH, a school-based, longitudinal study of an ethnically diverse cohort of adolescents living in London. This thesis focuses on two measures of body size, BMI and waist circumference, however ethnic differences in rates of overweight and obesity are also described. The main objectives were:

1. To examine trends in anthropometric measures (height, weight, BMI, waist, hip and waist hip ratio) between early and late adolescence and to determine if there were ethnic differences in these trends.

2. To determine what proportion of the variance in body size (BMI and waist circumference) was due to differences between schools, and whether school characteristics [general (denomination, sex, school size, expenditure); SES (free school meals, absenteeism, academic performance); social environment (ethnic density, English as a second language); ethos (well-being, behaviour, enjoyment, support)] were related to body size.

3. To determine what proportion of the variance in body size (BMI and waist circumference) was due to differences between neighbourhoods, and whether neighbourhood characteristics (deprivation, crime, ethnic density, and land use) were related to body size.

4. To examine which individual and family characteristics were related to body size (such as pubertal status, diet, physical activity, smoking behaviour, family SES, acculturation, and parental health behaviours).

5. To examine whether neighbourhood or school characteristics remained significant correlates of body size after adjustment for individual and family characteristics.

6. To assess whether the neighbourhood, school, individual or family characteristics explained any of the ethnic differences in BMI SDS, Waist SDS or overweight/obesity.

This thesis is comprised of eight chapters plus an appendix. Methods are described in Chapter 2, followed by results in Chapters 3 to 7. In Chapter 3 trends in the anthropometric measures are presented, and gender and ethnic differences detailed, and the impact of pubertal status described. Chapter 4 focuses on schools, Chapter 5 on neighbourhoods, and Chapter 6 on individual and family characteristics. In each of these chapters ethnic, age, and gender differences in the characteristics are discussed and the impact of these characteristics on body size after adjustment for the baseline covariates is described. The last section of each of these chapters details which variables were selected for inclusion in final multivariate models which adjust for neighbourhood, school, and individual/family characteristics. These final models are presented in Chapter 7. Chapter 8 discusses the findings, the strengths and limitations of this study, and suggests implications for policy and future research.

2 Methods

The first section of this chapter describes the sources of data used in this study, how data were cleaned, and the derivation of variables. In the second section, the extent of missing data and how it was dealt with are discussed. Finally, in the third section the statistical methods used and analysis undertaken are detailed.

2.1 Data

The individual level data (e.g. body size measures, and individual and family characteristics) came from the DASH (Determinants of Adolescent Social well-being and Health) study. Objective measures of the adolescents' neighbourhoods were from routinely collected government statistics, and the DASH schools were characterised using a range of government data sources.

2.1.1 Individual and family data

2.1.1.1 General overview of DASH

This section will give an overview of the DASH study; further details can be found in the cohort profile (Harding et al., 2007) and on the study's website (http://dash.sphsu.mrc.ac.uk/). DASH is a school-based longitudinal study of adolescents in London. It was designed to examine the influence of social conditions on the health and well-being of ethnic minority adolescents. The first wave was conducted in 2002-2003 when the pupils were aged 11-13yrs (referred to hereafter as Wave 1) and the second in 2005-2006 when the pupils were 14-16yrs (Wave 2). Over 6500 pupils from 51 schools took part in Wave 1. The schools were located in ten London boroughs (Brent, Croydon, Hackney, Hammersmith & Fulham, Haringey, Lambeth, Newham, Southwark, Waltham Forest, and Wandsworth) (Figure 2.1). These boroughs were selected as they had large numbers of ethic minority residents. Within each borough, the selected schools covered a range of academic performance levels and all had at least 5% of their pupils being of Black Caribbean descent. Classes of Year 7 and Year 8 pupils (the first and second years of secondary school in England) were randomly selected in each school to participate in the study at Wave 1. The same pupils participated in Wave 2 when they were in Year 10 and 11 (their fourth and fifth years of secondary school) (Table 2.1).

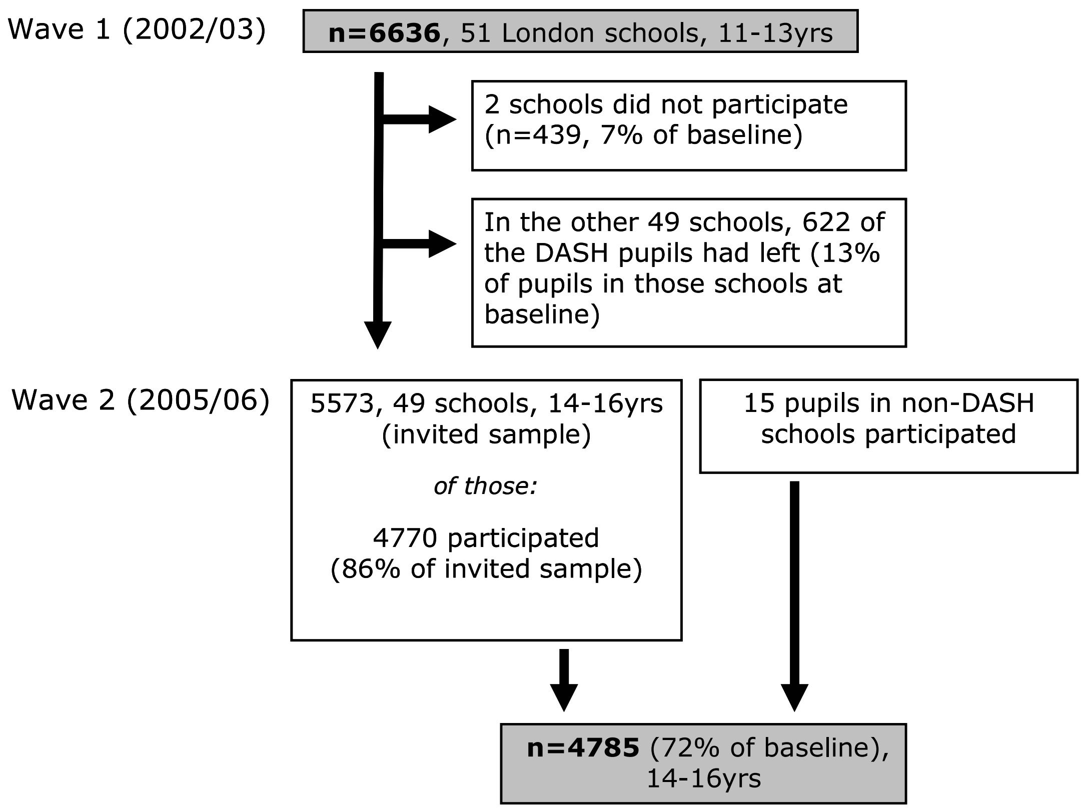
Figure 2.1 Map of London boroughs and location of DASH schools

Table 2.1 Organisation of school system in England

	School Year	Age on 1st Sept	Curriculum Stage	School	
	Year 1	5	Key Stage 1	Infant School	Primary School
	Year 2	6			
	Year 3	7	Key Stage 2	Junior School	
	Year 4	8			
	Year 5	9			
	Year 6	10			
Wave 1	**Year 7**	11	Key Stage 3	Secondary School	Secondary School with Sixth Form
	Year 8	12			
	Year 9	13			
Wave 2	**Year 10**	14	GCSE / Key Stage 4		
	Year 11	15			
	Year 12	16	Sixth Form / A Level	Sixth Form College	
	Year 13	17			

There was attrition between the two Waves of the study (Figure 2.2). Of the 51 schools which participated in Wave 1, two could not participate in Wave 2. Of the DASH pupils in the 49 schools which did participate in Wave 2, 13% had moved from the school they were in at Wave 1. If they had moved to another school in the Greater London area every effort was made to include them in the study however this resulted in only an additional 15 pupils taking part. Of those who were still at their Wave 1 school (the 'invited sample') 86% participated. Reasons for non-participation included: being absent (5% of invited children); pupil refusal (3%); and parental refusal (2%). Overall, the Wave 2 sample of 4785 represented 72% of the Wave 1 sample.

Figure 2.2 DASH sample size and attrition



2.1.1.2 The DASH longitudinal Sample

The ethnic composition of the longitudinal sample (i.e. the 4785 pupils who participated in both Waves) is shown in Table 2.2. Generally, the ethnic composition of the sample was similar for girls and boys. Two notable differences were the larger proportion of Nigerian/Ghanaian girls than boys and the larger proportion of Pakistani/Bangladeshi boys than girls.

Table 2.2 Ethnicity of the longitudinal sample, overall and by gender

	Overall		Boys		Girls	
	N	(%)	N	(%)	N	(%)
White UK	873	(18.2)	492	(18.8)	381	(17.6)
Black Caribbean	779	(16.3)	390	(14.9)	389	(17.9)
Nigerian/Ghanaian	505	(10.6)	207	(7.9)	298	(13.7)
Other African	387	(8.1)	210	(8.0)	177	(8.2)
Indian	419	(8.8)	237	(9.1)	182	(8.4)
Pakistani/Bangladeshi	446	(9.3)	306	(11.7)	140	(6.5)
Mixed	550	(11.5)	283	(10.8)	267	(12.3)
White Other	463	(9.7)	265	(10.1)	198	(9.1)
All Others	360	(7.5)	223	(8.5)	137	(6.3)
Not stated	3	(0.1)	2	(0.1)	1	(0.1)
TOTAL	*4785*	*(100)*	*2615*	*(100)*	*2170*	*(100)*

In the analysis for this thesis the sample was restricted to pupils in the longitudinal sample who belonged to one of the main ethnic groups (White UK, Black Caribbean, Nigerian/Ghanaian, Other African, Indian, and Pakistani/Bangladeshi) as only individuals from these groups were invited to have physical measurements taken at Wave 2. This gave a sample of 3409 pupils. A further 8 individuals were dropped as they were not attending a DASH school in Wave 2. The final sample therefore consisted of 3401 individuals; 54% boys (n=1837) and 46% girls (n=1564). This was 81% of the children in the main ethnic minority groups who were invited to participate in Wave 2.

2.1.1.3 Summary of the fieldwork stage

Prior to commencing my PhD, I was involved in the fieldwork for DASH Wave 2. The DASH fieldwork team consisted of four researchers (one being myself), two administrators, two nurses, and approximately 15 survey assistants. Most schools were visited for two full days. In addition, schools had at least one ‘mop-up’ visit to survey pupils who had been absent or unable to take part during one of the main study days.

Generally pupils completed the DASH questionnaire during their first school period (approximately 50 minutes). This was done under exam-like conditions, usually in the school hall. In order to maintain confidentiality, school staff were not present. The survey assistants provided assistance in completing the questionnaire where necessary. At Wave 1 all pupils were then invited to have physical measures taken; at Wave 2 only those in the main ethnic minority groups were measured due to time and budget constraints.

2.1.1.4 Individual and family measures in DASH

The DASH questionnaires included measures of socioeconomic circumstances, physical activity, diet, parental behaviours, and ethnicity. The questionnaires can be viewed online (http://dash.sphsu.mrc.ac.uk/researchers-questionnaires-and-measurements.html). The choice of individual and family variables was informed by previous work on DASH. Analysis of the Wave 1 data had revealed several individual and family variables to be associated with overweight and/or obesity at 11-13yrs; skipping breakfast, maternal smoking, maternal overweight, and generational status (Harding et al., 2008b). These variables, plus others thought to be potentially important correlates of body size, were selected for inclusion. Table 2.3 summarises the selected demographic, socio-economic status (SES), and acculturation measures; Table 2.4 the pupil behaviour measures; and Table 2.5 the parental measures. Further details are provided in the text for some of the measures. Unless otherwise stated, measures were identical at both Waves.

Table 2.3 Demographic, socioeconomic status, and acculturation measures in DASH

Variable	Categories/or continuous	Comment
Demographics		
Gender	Boy; girl	
Age	Continuous	Calculated by subtracting date of birth from study date.
Ethnicity	White UK; Black Caribbean; Nigerian/Ghanaian; Other African; Indian; Pakistani/Bangladeshi	Consistency with parental ethnicity and country of birth was checked.
Socio-economic circumstances		
Standard of Living Items	Quartiles. Q1=highest number of items (i.e. least deprived).	Quartiles of 19 item score (car/van, CD player, DVD player, garage, bedrooms, television, telephone, computer, toilet, holiday abroad, fridge freezer, dishwasher, private garden, washing machine, microwave, digital TV, tumble dryer).
Family type	Two parent; one parent; other	'Parent' includes step-parent.
Parental employment	≥1 parent working; no parent working; no resident parent	Working includes full and part time. Not working includes full-time education, unemployed, housework, sick/disabled.
Overcrowded home	Yes; No	Parent(s) were assumed to have one bedroom; a home was categorised as overcrowded if an average of more than 2 people shared each of the other bedrooms.
Acculturation		
Generational-status	Born in UK or lived in UK for >10yrs; born abroad and lived in UK for <10yrs	Measured at Wave 1.
Language Use in home	English only; other languages	
Attendance at place of worship	≥1 per week; once a month; few times a year; never	
Friends of different ethnicity to self	Most or all; quite a lot; some or none	

Table 2.4 Pupil behaviour measures in DASH

Variable	Categories/or continuous	Comment
Diet		
Fruit and vegetable consumption	≥5 portions per day; 1-4 per day; <1/none per day	
Eating breakfast	Everyday; not everyday	Wave 1 only.
Physical Activity/Sedentary Activities		
No. of different activities in 7 days	Quartiles. Q1=lowest number of different activities.	Not measured in same way at both Waves.
No. of activity sessions in 7 days	Quartiles. Q1=lowest number of activity sessions.	Not measured in same way at both Waves.
No. of breathless activity sessions in 7 days	Quartiles. Q1=lowest number of breathless activity sessions.	Wave 2 only.
Total time active in 7 days	Quartiles. Q1=least time.	Wave 2 only.
Total time in breathless activity in 7 days	Quartiles. Q1=least time.	Wave 2 only.
Active transportation	No active transport; Active transport to and/or from school	Wave 2 only. Active transportation refers to commute to/from school and includes walking and cycling.
Sedentary time	Quartiles. Q1=least sedentary time.	Wave 2 only. Score based on list of items: talking on the phone; text messaging; using email/internet; watching TV; playing computer games; reading or listening to music.
Smoking	Never; tried once; given-up; smoker	Smoker includes those who reported smoking 'regularly' (≥1 cigarette per week) or 'occasionally'.
Sleep on average night	≤6hrs; 7hrs; 8hrs; 9hrs; ≥10 hours	Wave 2 only. Times rounded to nearest hour.

Table 2.5 Parental behaviour measures in DASH

Parental Behaviours		
Parental Smoking	Yes; no; not resident	Smoking status of resident parent(s) only. Separate variables for mother and father.
Parental Overweight	Yes; no; don't know; not resident	Weight status of resident parent(s) only. Separate variables for mother and father.

Ethnicity

Pupils reported the ethnicity of themselves and their parents by selecting from a list of ethnic groups based on categories used in the 2001 England and Wales Census (ONS, 2001) (Table 2.6). Pupils were also asked to report the country of birth of themselves, their parents, and their grandparents. Data were checked for consistency between reported ethnicities and countries of birth, and consistency across the generations of the family (Harding et al., 2007).

Table 2.6 Summary of ethnic group categories in DASH questionnaire

Ethnic Group Section	Options available in section
White	UK; Irish; Greek; Turkish; Jewish; Kurdish; Other
Black	Somali; Ugandan; Nigerian; Ghanaian; Other African; Caribbean; Black British; Other
Asian	Indian; Pakistani; Bangladeshi; Chinese; Vietnamese; Other
Mixed	White and Black Caribbean; White and Black African; White and Asian; Other

The Nigerian/Ghanaian group were coded separately from the Other African group due to the differences in their migration histories and socioeconomic circumstances in the UK (Mitton and Aspinall, 2010). It was not possible to disaggregate the Other African group further due to small numbers. The Pakistani and Bangladeshi groups were combined due to the Pakistani group being too small to analyse on its own; both of these groups are more economically disadvantaged than Indians in the UK and both have raised cardiovascular risk in adulthood.

Family socio-economic status (SES)

The proxy measures of family SES had to be appropriate for the age of the pupils (e.g. it is unlikely that they could have accurately reported household income or parental education level). Four measures were used: standard of living items; family type; parental employment; and overcrowding (Table 2.3). The standard of living score has been used in previous DASH publications and it was able to distinguish between the socio-economic circumstances of the different ethnic groups (Harding et al., 2008c, Harding et al., 2008b). In Wave 1 pupils had to select which from a list of 17 items they had at home; in Wave 2 an extra two items were added to the list (internet at home and mobile telephone). In the Wave 1 questionnaire, a separate question had asked about mobile phone ownership and internet access and so these items were added to the original 17 item Wave 1 scale in order to make it directly comparable to the Wave 2 measure. The total number of items was summed and quartiles of the score were calculated for the whole sample at Wave 1 and these cut-offs were then applied to the Wave 2 data. Family type was also used as a proxy of SES as lone parents are generally more disadvantaged than two parent families. Parental employment (i.e. working or not working) was used rather than parental occupation due to large amounts of missing data at 11-13yrs resulting from the pupils not knowing this information.

Acculturation

Generational status can be viewed as both a proxy measure of acculturation and of socioeconomic status; families who had migrated more recently may have been more likely to have traditional practices and to be of lower socio-economic status than those who had been in the UK for several generations. Pupils reported their country of birth and how long they had lived in the UK for. It should be emphasised that the length of time resident in the UK refers to when the pupils were aged 11-13 years (Wave 1). Therefore any of the DASH pupils who reported having lived in the UK for >10 years would have moved to the UK as an infant. For this reason they were combined with those who reported having been born in the UK. Additional acculturation measures in DASH include: language use, frequency of attendance at a place of worship; and how many of their friends were a different ethnicity to themselves. Those who spoke languages other than English at home, who frequently attended a place of worship, and whose friends were predominately the same ethnicity as themselves were considered more likely to be exposed to more traditional values.

Parental behaviours

The smoking status of resident mothers and fathers was ascertained from two items in the questionnaire. One question was on parental health and included an item on smoking. The other was a question on smoking status of household members. If pupils reported their parent’s smoking status inconsistently (e.g. reporting that they were smokers in the first question and non-smokers in the second) then parental smoking status was coded as missing. Pupils were asked whether their resident parents ‘had problems from being overweight’ and had the option of saying they did not know.

Pupil behaviours

Dietary habits

Separate items asked about pupils' fruit and vegetable consumption and the information from these was combined to create an overall fruit and vegetable consumption measure. Pupils were asked in Wave 1 only how often they ate breakfast (either at home or at a school breakfast club).

Physical activity

There were several differences between the physical activity measures at Wave 1 and Wave 2. The Wave 1 questionnaire asked about sports and exercises in a typical week whereas Wave 2 asked about the previous 7 days; Wave 1 asked about evenings and weekends (i.e. when they were not at school) whereas Wave 2 included both in and out of school activities; in Wave 1 pupils only reported how often they did each of the activities (every day, most days, weekly, less than weekly or never) but at Wave 2 they reported how many times they had done it, how long they had spent doing that activity in total, and whether it had made them out of breath (no; a bit; a lot). So, for example, a pupil could report that they had played football 3 times in the previous 7 days, for a total of 2 hours, and that it had made them a bit out of breath.

At both waves, pupils had the opportunity to report an additional activity in an 'other' section if they did something that was not included in the list of activities. The 'other' activities listed by the pupils were assessed to see if they were eligible to be included. If the other activity was a duplicate or very similar to one already included then the corresponding item on the original list was recoded accordingly and the pupil had the other section recoded to none (i.e. no other activity). Other activities not already on the list had to require at least moderate cardiovascular activity to be included in analysis (e.g. circuits, rock climbing, aerobics, and cheer-leading). The activities not included were either deemed not to be physical activities or exercises (e.g. singing, computer games, cooking, band practice, and reading), or were too ambiguous for them to be included (these were activities which may have involved physical exertion but that could not be ascertained from the description given e.g. coaching football team; playing with dog; cadets; and gardening), or were activities that did not usually represent moderate cardiovascular activity (e.g. archery, bowling, and snooker). In all of these situations, the pupils had the other section recoded to 'none'.

Although the physical activity measures differed between the Waves, it was possible to derive two common variables. The total number of activities a pupil was involved in was calculated for each wave; this was viewed as a proxy measure of how sporty or interested in sport an individual was rather than as a measure of amount of physical activity. (However this measure could not capture a child who was very sporty but had chosen to specialise in a limited number of activities). At Wave 1 activities that were reported as having been done 'less than weekly' were not included since at Wave 2 the question asked about activities in the previous 7 days. It should be stressed that this 'total number of activities' variable does not include any information on how often an activity was performed. Quartiles of the total number of activities score were calculated.

The total number of sessions that a pupil reported was also calculated. For example at Wave 2, if a pupil reported swimming three times in the previous 7 days and having cycled once, they would have a total of 4 activity sessions. In Wave 1, as the number of sessions was not reported, the frequencies were given a score; 7 for an activity performed every day, 4 for most days, and 1 for weekly. The scores for all of the activities were summed to give a total score for each pupil. This score was a proxy for number of activity sessions. For Wave 2, a second variable was calculated with breathless activity sessions; this made the assumption that the respondent was breathless every time they performed an activity. So if a pupil said they played football twice and they report that this made them a bit out of breath, it was assumed they were a bit out of breath both times that they played. Quartiles of both these number of sessions variables were derived.

At Wave 2, a variable giving the total amount of time spent on the activities was calculated. This included every activity the respondent reported, including those where they said they did not get out of breath. A second total time variable was calculated but this time only including activities where the pupil reported that it made them a bit or a lot out of breath. This made the assumption that the pupil was breathless for all of the time they reported doing an activity. Quartiles of these time variables were derived.

At Wave 2 only pupils reported if they used active transportation (walking or cycling) to travel to/from school. Also at Wave 2, pupils were asked how long they had spent the previous day doing each of a list of sedentary activities. A score was derived where no time=0; less than an hour=0.5; 1-2 hours=1.5 etc. A total score was calculated by summing across the activities; quartiles of this score were calculated. At Wave 2 pupils also reported how many hours they usually slept for; times were rounded to the nearest hour and a categorical variable derived.

Smoking

Pupils reported their smoking status at both Waves. ‘Regular’ (defined in the questionnaire as one or more cigarettes per week) and ‘occasional’ (sometimes) were combined into ‘smoker’ due to the small number of pupils describing themselves as regular smokers. If they had ever tried smoking they also reported the age of their first cigarette and how many cigarettes they had smoked in the previous week. A small number of pupils reported their smoking behaviour inconsistently. For example a pupil may have reported that they had never tried smoking but that they smoked their first cigarette when they were 10. Similarly, a pupil may have reported that they were an ex-smoker but that they smoked 5 cigarettes in the past week. Pupils had their smoking status coded as missing where responses to questions were inconsistent.

2.1.1.5 Physical Measures in DASH

Pupils’ height, weight, waist and hip circumferences were measured at both Waves according to WHO and Health Survey for England protocols (Department of Health, 2001, WHO, 1995). Pupils also completed a pubertal stage questionnaire during the measurement session. All survey assistants received training on how to take the physical measures prior to the start of the study, and had refresher sessions during the study period.

Standing Height

Each pupil’s height was measured using a portable stadiometer. Height was recorded in centimetres to one decimal place. If a height was midway between two millimetres, it was recorded to the nearest even millimetre. Survey assistants repeated and confirmed the measurement of any pupil who was particularly short or tall. For example the thresholds at Wave 2 were: girls: <145cm or >175cm; boys: <145cm or >185cm.

Weight

Weight was measured using Salter scales at Wave 1 and Tanita Body Composition scales (model TBF 300) at Wave 2. Weight was measured in kilograms to one decimal place. If the pupil was very light or very heavy for their sex (boys: <35kg or >70kg; girls: <40kg or >75kg) measurements were repeated and confirmed.

BMI

BMI was derived as weight (kg)/height (m^2).

Waist and hip circumferences

These were measured, using a tape measure with a buckle, in centimetres to one decimal place. As with height, if the measurement fell between two millimetres, the measurement was rounded to the nearest even number. The waist was defined as the midway point between the iliac crest and the lower edge of the last rib. The hip was the widest circumference over the buttocks and below the iliac crest. Both the waist and hip measures were taken twice to ensure their accuracy. If the difference between the two measures was ≥0.5cm, a third measure was taken. The measurement used in analysis is the mean of the two closest measures which were ≤0.5cm apart. Waist-to-hip ratio (WHR) was derived.

Standard Deviation Scores (SDS)

Standard deviation (SD) scores were calculated for height, weight, waist circumference, and BMI. SD scores allow the different measures to be compared on the same scale and for the measures of the DASH pupils to be compared to a reference population. Values of the DASH pupils were standardised to the British 1990 Growth Reference in Excel using the LMS Growth add-in (version 2.64) (Pan and Cole, 2008). The aim of the 1990 Growth Reference was that it should be as nationally representative as possible; the curves for height, weight and BMI incorporated data from seven studies (25,000 individuals in total) which were collected between 1978 and 1990 (Freeman et al., 1995). The waist curves used measures taken in 1988 from over 8355 children across Great Britain (McCarthy et al., 2001). All of the growth curves were based on White children only; non-White children were excluded due to growth and adult body shape differences between ethnic groups. As the seven studies had small numbers of non-White children, it was not possible to produce separate growth curves for different ethnic groups. The Growth Reference curves are age and sex specific.

Pubertal Stage

Pubertal stage was self-reported using a Tanner Questionnaire (Tanner, 1962, Taylor et al., 2001). The questionnaire was explained to the pupils on a one-to-one basis by a study nurse and was completed in a screened-off area to ensure privacy. The boys’ version asked them to report their stage of development of pubic hair and genitalia; both scored on a five point scale (1 equalling pre-pubescent; 5 fully developed). The equivalent girls' questionnaire included items on pubic hair and breast growth; again, both were measured on a 5-point scale. Pupils were classified as pre-pubertal (Tanner stage 1 for breasts or genitalia and pubic hair), early puberty (Tanner stages 2 and 3 for breasts and genitalia), or late puberty (Tanner stages 4 and 5). For both boys and girls, a binary variable was created: pre/early/mid puberty versus late puberty. Small numbers of pupils were in pre or early puberty at either Wave.

2.1.1.6 Subjective Neighbourhood and School Measures in DASH

The DASH questionnaires contained four items about the residential neighbourhood of the pupils. Pupils reported whether they strongly agreed, agreed, disagreed or strongly disagreed with the statements about the area in which they lived: 'I like this area', 'I feel safe in this area during the day', 'I feel safe in this area at night', 'other people think this is a good area'. Responses were dichotomised into strongly agree/agree versus disagree/strongly disagree.

At Wave 1 only, the pupils were asked two items about their teachers. Pupils reported whether they strongly agreed, agreed, disagreed or strongly disagreed with the statements: 'I like most of my teachers' and 'I have at least one teacher that really encourages me'. Responses were dichotomised into strongly agree/agree versus disagree/strongly disagree. Responses were also aggregated up to school level which gave the proportion of pupils in a school who liked their teachers/felt encouraged by them. Quartiles of these aggregate variables were calculated.

2.1.2 Neighbourhood Data

Both the residential postcodes and the postcodes of the schools were linked to routinely collected neighbourhood statistics data in order to characterise the areas in which the DASH pupils lived and attended school. Neighbourhoods were characterised in terms of their deprivation and crime levels, ethnic density, and land use. Linkage was done at the Lower Super Output Area (LSOA) level. England is split into 32,482 LSOAs; they have a minimum population of 1000 and a mean population of 1500. LSOAs in London have an average area of $0.33km^2$. LSOAs are formed from groups of Output Areas, which are the areas used in the Census.

Schools reported pupils' residential postcodes at Wave 1, and pupils self-reported at Wave 2. For pupils who did not report a postcode but who did report an address, the appropriate postcode was found and used. For those who reported an incomplete postcode or a postcode which was in the wrong format (e.g. one starting with a number rather than a letter), original questionnaires were checked for data entry errors and postcodes corrected where errors were found.

The neighbourhood-level data were downloaded from the Office for National Statistics (ONS) website of neighbourhood statistics (www.neighbourhood.statistics.gov.uk). The data files used are detailed in Table 2.7. The information described in this section was obtained from the PDFs which can be downloaded to accompany each dataset. Each of the datasets was downloaded as a Microsoft Excel file and the required variables imported into Stata, where they were merged with the individual-level data.

Table 2.7 Neighbourhood Statistics data used

Dataset Title	Dataset File name	Time Period	Wave of DASH linked to
Indices of Deprivation 2004 for Super Output Areas in England	JA1A0304_801_GeoPolicy.xls	2001-2002	1
Indices of Deprivation 2007 for Super Output Areas in England	J340307_1894_GeoPolicy.xls	2004-2006	2
Ethnic Group (KS06)	KS060301_48_GeoPolicy_UK.xls	2001	1 & 2
Land Use Statistics (Generalised Land Use Database) England, 2001	H240301_1202_GeoPolicy_UK.xls	1st November 2001	1
Land Use Statistics (Generalised Land Use Database) England, 2005	H240305_1617_GeoPolicy_UK.xls	January 2005	2

2.1.2.1 Neighbourhood Deprivation and Crime

The Index of Multiple Deprivation (IMD) is an area-based deprivation index which is comprised of seven domain indices, each measured at the LSOA level. Each of the domains covers a different aspect of deprivation: income, employment, health, education, housing, crime and living environment (Table 2.8). The IMD therefore treats deprivation as a multi-faceted concept, explicitly acknowledging that there are varied types of deprivation that can affect residents of an area.

In each of the LSOAs in England a score is assigned for each of the deprivation domain indices. For most of the domains, the score is calculated by linking individual-level data to residential postcodes then aggregating the data at LSOA level. For crime and accident data, a buffer is created around each event's location and the number of events proportionately distributed between all of the LSOAs that cover a part of that buffer zone. The buffer zone is larger for crimes than for accidents (100m and 10m respectively).

The scores for each of the seven domains are then combined into an overall score, with each of the different domains contributing a different amount to this overall score due to differential weighting; the income and employment domains contribute the most to the overall IMD score (Table 2.8). The LSOAs are then ranked from most to least deprived for each of the 7 domains, and for the overall IMD score. In each case, the LSOA ranked 1st is the most deprived, and the one ranked 32,482nd the least deprived. The scores of the different domains cannot be directly compared as they are on different scales; therefore comparison between domains can be based only on the ranks.

Table 2.8 Domains of the Index of Multiple Deprivation

Domain Index	Weight	Definition
Income Deprivation	22.5%	Proportion of population that is living in low income families (defined as those reliant on means tested benefits).
Employment Deprivation	22.5%	Proportion of working age population (women aged 18-59yrs, men aged 18-64yrs) who are involuntarily excluded from work (includes those out of work due to illness or disability).
Health deprivation and disability	13.5%	Areas with relatively high rates of people dying prematurely (<75yrs), or with impaired quality of life due to poor health or disability.
Education skills and training deprivation	13.5%	Has two sub-domains: - lack of educational attainment of young people - lack of qualification and skills in working age adult population (25-54yrs)
Barriers to housing and services	9.3%	Barriers to housing and geographical barriers to key local services e.g. GP premises, supermarkets, primary schools and post offices.
Crime	9.3%	The rate of crime (burglary, theft, criminal damage, and violence). These types of crime reflect personal and material victimisation in an area.
Living Environment deprivation	9.3%	Has two sub-domains: - Indoors: quality of housing - Outdoors: measures of air quality and road traffic accidents

Adapted from IMD04/IMD07 PDF Information Documents

The postcodes of the DASH pupils and schools were linked to the overall IMD and to the crime domain. The 2004 data were linked to Wave 1 (2002/2003), and the 2007 data to Wave 2 (2005/2006). Despite its name, most of the indicators used to produce the 2004 dataset are based on 2001 data. The 2007 dataset is an update of the 2004 dataset. Most of the indicators are based on 2005 data, with some 2004 and 2006 data also being used, as well as some 2001 Census data. Although some of the indicators used to create the 2004 and 2007 datasets differed, the majority of the differences between these datasets were due to updates to the data rather than additions or changes to the indicators, and it is therefore possible to compare the ranks of the domains, and the overall IMD, at the two time points.

Quintiles of the ranks of the IMD and crime domain were derived; these quintiles were based on the whole of England, with LSOAs in quintile 1 (Q1) of the IMD variable being the most affluent, and those in quintile 5 (Q5) being the most deprived. Similarly, areas in Q1 of the crime variable had the lowest crime rates, and those in Q5 the highest.

2.1.2.2 Ethnic Density

The ethnic density data were from the 2001 census and details the percentage of the total population in an area (LSOA) that each ethnic group comprised. As this was Census data both the Wave 1 and Wave 2 residential postcodes, and the school postcodes at both time points, were linked to the same data.

There were 16 ethnic group categories in the 2001 Census in England: White British, White Irish, White Other, Mixed White and Black Caribbean, Mixed White and Black African, Mixed White and Asian, Mixed Other, Indian, Pakistani, Bangladeshi, Other Asian, Black Caribbean, Black African, Black Other, Chinese, and Other. Respondents were asked to record the 'perceived ethnic and cultural background of usual residents' at their home. There were no missing data (i.e. no 'not stated' category) in this dataset as missing values were imputed by National Statistics based on responses to other Census questions.

For analysis, quartiles of own ethnic density were calculated (with density being the proportion of an area's population belonging to a given ethnic group). Quartiles were based on LSOAs in the sample. For example, for the White UK pupils quartiles of White British were derived (Q1=lowest density). Quartiles of Black African neighbourhood density were derived separately for the Nigerian/Ghanaian and Other African pupils. Neighbourhood Pakistani and Bangladeshi densities were combined and quartiles calculated for the Pakistani/Bangladeshi pupils.

2.1.2.3 Neighbourhood Land Use

The neighbourhood land use datasets detail what land types an area consists of; the classification system allocates all identifiable land features to one of 9 simplified land categories: domestic buildings; non-domestic buildings; roads; paths; rail; gardens (domestic); greenspace; water; other. There is also an unclassified category. The allocation of land to each of these types is done by a computerised process. The amount of land of each type within an area is given in thousands of meters squared ($000m^2$) to 2 decimal places and is accurate to the nearest 10 m^2. The total land area is also given. Land

Use data were available for 2001 and 2005. The two datasets were created using a similar process, however this process was improved over the intervening years resulting in more accurate data in 2005, and ONS state that the 2005 figures are not comparable with 2001. Wave 1 postcodes were linked to the 2001 data and Wave 2 postcodes to the 2005 data. After the data were imported into Stata, the proportion of the total land area that each land type consisted of was calculated. Quartiles of these proportions were derived (Q1 being the lowest proportion of land use, Q4 the highest).

2.1.3 School Data

Three sources of school data were used: the school census, exam performance tables, and reports from Ofsted (Office for Standards in Education, Children's Services and Skills, the official body for inspecting schools in England). First these sources and their strengths and weaknesses are discussed, and then the measures are detailed.

2.1.3.1 Data sources

School Census

All local education authority maintained schools are required to complete the annual school census every year (Department for Education, 2011a). The census covers a range of items at both the child and school level. The data are held by the Department for Children, Schools and Families (DCSF) and are available free of charge on request. These data have the advantage of being routinely collected in a systematic way from all schools at the same point in time.

School census data from 2003 and 2006 were used to characterise the schools at Wave 1 and Wave 2 respectively. As the census takes place in the January of each year, the 2003 and 2006 censuses would have taken place mid-way through each of the data collection periods. Variables of interest were identified from the website and the following were provided: ethnicity of pupils in each school; percentage of pupils who do not speak English as a first language; proportion of pupils eligible for free school meals; proportion of pupils with special educational needs. The data were provided in a Microsoft Excel spreadsheet which was cleaned and imported into Stata.

Examination Performance Tables

The Department of Children, Schools and Families (DCSF) produce annual 'school and college achievement and attainment tables' (formerly known as performance tables). The tables for the different academic levels (e.g. Key Stage 3, GCSE) can be downloaded from the DCSF website (www.dcsf.gov.uk/performancetables/). As these tables are published each year, it was possible to compare schools at the same point in time.

To represent the learning environments of the schools during the periods that DASH took place, 2003 reports were selected for Wave 1, and 2006 reports for Wave 2. Two schools did not have a 2003 report as the school only opened in 2003 under that name, therefore 2002 reports were used. For the same reason, one school did not have a 2006 report therefore 2005 reports were used. Key Stage 3 (KS3) reports were selected for 2003 as KS3 refers to the first three years of secondary schooling (Years 7, 8 and 9); the DASH pupils were in Years 7 and 8 at Wave 1. GCSE reports for 2006 were used to capture the academic performance of the school during Wave 2; GCSE subjects are studied in Year 10 and 11, with the examinations being sat at the end of Year 11.

Ofsted Reports

All state schools and colleges are legally required to have Ofsted inspections, and these are done on a three-year cycle. A report of each inspection is available for download from the Ofsted website (www.ofsted.gov.uk). Data from these reports were used to try to capture the ethos and atmosphere in the schools. Ofsted state that their reports give a 'comprehensive and impartial' review of each school and they were therefore considered a good source of data with which to characterise aspects of the DASH schools not covered by the census or DCSF data.

A table was compiled detailing all of the reports available from 1999 to present for each school. An initial examination of a sample of reports revealed that the format of the Ofsted reports changed considerably in 2005. The two formats contained different data and were therefore not possible to compare. For Wave 1 it was decided to take reports from the study years plus one year before and after this period; therefore reports from 2001-2004 were eligible. No school had more than one report in this time; 15 schools did not have a report. It was not possible to take reports from before the study period of Wave 2 due to the change in the format of the reports. Therefore late style reports from 2005 and reports from 2006 and 2007 were eligible. No school had more than one eligible report in this time period; nine schools did not have a report. Of these 9 schools, 2 of them do not have a Wave 1 report either. Therefore 2 schools had no eligible Ofsted data from either of the Waves.

The selected reports were downloaded from the website. For reports that were not available online (e.g. schools that had changed their name), Ofsted were contacted directly. Initially a sample of approximately 10 reports was taken from each Wave. These were used to compile spreadsheets detailing which variables were available and how consistently they were reported. Items that were included in the majority of reports and which were recorded in a standardised manner were eligible for inclusion. Data were then extracted from the reports for each school. Despite the limitations of the Ofsted data, its strength is its inclusion of variables not found in the other data sources.

2.1.3.2 School level variables

General school characteristics

Data on school religious affiliation (non-denominational, Church of England, or Catholic) and school sex (mixed, all boys, or all girls) were obtained from the schools' websites. Data on the size of the school (i.e. total number of pupils) was obtained from the school census datasets. Expenditure per pupil was available in the Wave 1 Ofsted reports.

Measures of social environment

Ethnic density (school census)

The ethnic group categories in the school census were: White British; Irish; Irish Traveller; Other White; Gypsy/Roma; White and Black Caribbean; White and Black African; White and Asian; Other Mixed; Indian; Pakistani; Bangladeshi; Other Asian; Caribbean; African; Other Black; Chinese; Other. In the 2003 data, the number of pupils in each ethnic group was given for each school. The total number of pupils classified to an ethnic group, and the percentage of all pupils who were classified to an ethnic group was also provided. If a school had a small number of pupils in a given ethnic group then the actual number was not provided, and at least two ethnic groups would have a symbol rather than a figure to ensure that it was not possible to calculate how many individuals were in these groups. According to DCSF, these symbols usually refer to 1 or 2 pupils. I have taken them to be equal to 1.

The total number of pupils in each school was calculated by dividing the number of pupils classified to an ethnic group by the percentage of pupils who were classified to an ethnic group, and then multiplying by 100. This variable was then rounded to the nearest whole number to give the school population. The number of pupils in each ethnic group was then divided by the school population and multiplied by 100 to give the percentage of each ethnic group in a school. In the 2006 data, the ethnic group percentages were already provided and so none of the above calculations were necessary. Quartiles of own ethnic density were calculated in the same way as described for the neighbourhood ethnic density data.

Not speaking English as a first Language (school census)

Both the 2003 and 2006 datasets gave the percentage of pupils in each school whose first language was known or believed to be other than English. This variable was selected to be a measure of cultural diversity in a school. However this variable does not give any information on which languages the children spoke, the total number of languages spoken in a school, or on a pupil's English ability (i.e. English may not be the child's first language but they may speak it fluently).

Measures of school socio-economic status

School SES refers to the socio-economic circumstances of the pupils who attend each school. The SES of a pupil's peers could be associated with body size over and above individual SES, for example through reinforcing social norms.

Free school meals (school census)

The proportion of pupils receiving free school meals is a measure of school socio-economic status as eligibility is based on parental income. Children of those on income support, job seekers' allowance, or who receive child tax credit and whose income does not exceed a given threshold (£16,190 in 2011) are eligible (Directgov, 2011). A limitation is that the proportion only includes pupils who are actually receiving free meals, it does not include pupils who are eligible but whose parents have not applied.

Academic performance and progress (DCSF)

Academic performance was also used as a proxy of school SES. Family SES is a strong correlate of academic achievement, however the strength of the association can vary by other characteristics such as ethnicity and neighbourhood of residence (Sirin, 2005). The

KS3 average point score (APS), based on national curriculum tests taken at the end of Year 9, was used to characterise the academic environment of the school at Wave 1 (Equation 2.1). Quartiles of APS were calculated (Q1=highest academic achievement). The variable chosen to capture the academic performance of the school during Wave 2 was the percentage of pupils achieving five or more GCSEs at Grades A*- C including English and Maths. Quartiles were calculated (Q1=highest academic achievement).

Equation 2.1 Definition of Key Stage 3 Average Point Score (APS)
APS=(Total points for English + Total points for maths + Total points for science) / (Total number of eligible pupils for each subject)

Absenteeism (DCSF)
Absenteeism is used as the third proxy school SES measure. Child poverty has been found to be closely related to truancy (Zhang, 2003). In addition to poverty, absenteeism is associated with other measures of disadvantage such as living in disorganised and unsafe neighbourhoods that lack adult supervision (Kearney, 2008). Attendance data was taken from the 2003 and 2006 GCSE reports. The attendance data had two variables: authorised and unauthorised absence. Unauthorised absence includes all unexplained absences, and it also includes pupils who are late and arrive at school after registers have closed (the DCSF recommend that pupils more than 30 minutes late be recorded as absent). These variables give the percentage of half days missed. Quartiles of absenteeism were calculated (Q1=lowest absence rates).

Proportion on Pupils with Special Educational Needs (school census)
The proportion of pupils with special educational needs (SEN) in a school will influence the overall academic performance of the school and will likely affect the learning environment. Children with SEN have learning difficulties or disabilities that make it harder for them to learn than other children the same age as them (Department for Education, 2011b). However not all children with learning difficulties have SEN. For example, those who do not speak English as a first language may have difficulties learning, but if this is a pupil's only reason for having learning difficulties then they are not counted as having SEN. Mainstream schools can meet the additional needs of most children with SEN, but if they cannot then the Local Authority can make 'a statement of SEN' (usually called 'a statement'). A statement details all of a child's SEN and the help that they should receive. Both the 2003 and 2006 school census datasets give the percentage of pupils who

had SEN with and without statements. Quartiles of the proportion were calculated for both measures (Q1=lowest proportion).

School Ethos

Personal development and well-being (Ofsted)

The Wave 2 Ofsted reports included a range of 'Personal Development and Well-Being' items, some of which were selected to characterise the ethos of the schools (Table 2.9). The overall personal development and well-being score assigned to each school was also included. Although the Wave 1 reports contained information on pupil behaviour and attitudes to school, these items were less standardised than those in Wave 2 and so were not used. All of the variables were coded 1-4 (1=exceptionally high; 2=above average; 3=average; 4=exceptionally low). Truancy rates are inversely related to enjoyment of school, and connectedness to school and teachers, and so could also be considered a proxy measure of ethos (Kearney, 2008, Veenstra et al., 2010).

Table 2.9 Ofsted measures of school ethos

Personal development and well-being items[1]
Overall personal development and well-being of the learners
The extent of learners' spiritual, moral, social and cultural development
The behaviour of learners
The extent to which learners adopt healthy lifestyles
How well learners with learning difficulties and disabilities make progress
How well learners enjoy their education
How well are learners cared for, guided and supported

[1] included in Wave 2 Ofsted Reports

2.2 Data cleaning, missing data and imputation

2.2.1 Data cleaning

2.2.1.1 Categorical Variables

All categorical variables were checked for data entry errors (i.e. categories that did not exist) or inconsistences with responses to another questionnaire item. Where responses were inconsistent (e.g. for parental smoking) an 'inconsistent' category was derived. This was later recoded to 'missing' to allow values to be imputed.

2.2.1.2 Continuous Variables

The continuous variables were checked for extreme values, and inconsistency between measures or between Waves. Each of the measures which required cleaning is described in turn.

Body Size Measures

Extreme values

Extreme values for height, weight, waist and hip were carefully examined to determine whether they were plausible. This was done by: comparing values, and their percentile scores, with other body size measures (e.g. did those with extremely high weights also have large waists); comparing values at Wave 1 and Wave 2 (e.g. were those who were very tall at Wave 1 still tall at Wave 2); and checking the sex and ethnicity of those with extreme values. In total, only one height measure, two weight measures, and one waist measure were implausible; these were recoded to missing.

Difference between waves

The differences in values between Waves were checked to ensure that the amount of weight/height/waist circumference gained (or lost) was plausible. Small decreases in height (<0.5cm) were found for 8 pupils and were assumed to be due to a slight measurement error at one or both Waves; in this case, the Wave 1 height was assumed to be correct (the taller height), and replaced the Wave 2 height. Twenty people had a height difference between -8.1cm to -0.5cm. All of the measured heights were plausible; the Wave 1 height was assumed to be correct, and the Wave 2 height was recoded to missing. One individual had a negative difference in height between the Waves much larger than any of the others; this White UK girl was measured at 158.1cm (centile 67.6) at Wave 1, and 125.4cm (centile 0) at Wave 2 giving a difference of -32.7cm. The Wave 1 height was deemed most plausible given the percentile values and the corresponding BMI values for each height (BMI of 24.2 at Wave 1 and 49.5 at Wave 2). The Wave 2 height was recoded to missing.

Differences in weight between the Waves were then examined. The mean weight difference between Wave 1 and Wave 2 was 9.79kg. However, the range was large: -91.9kg to 48.1kg. These values seemed implausible given that the mean time between the two measurements was only 2.6 years (range 2.2 to 3.5 years). Three pupils had lost 80kg or more (over 12.5 stone) but had increases in their hip and waist measures between Wave 1 and Wave 2. This suggested no weight loss occurred. Furthermore, the waist and hip measures suggest that the high Wave 1 measures were inaccurate; these were recoded to missing. The hip and waist measures of all those who had a weight loss of more than 12kg were checked. In most cases waist and hip measures reduced, confirming weight loss had occurred. However, in one case, a Black Caribbean girl who lost 38kg, the reduction in waist and hip measures was small and did not reflect such a large loss in weight. The Wave 1 measure was recoded to missing.

BMI was calculated for each individual from the cleaned height and weight measures. The measurements (height, weight, waist, hip, and BMI at both Wave 1 and Wave 2) were examined for the individuals with the highest and lowest BMIs at each Wave. At both Waves pupils with low (<14) and high (>35) BMIs had waist and hip data consistent with such BMI values.

At both Waves, waist and hip were measured twice. Where the two measurements were >0.5cm apart, a third measure was taken. The mean waist was calculated as the average of the two closest measures. For Waist, at Wave 1, 182 pupils had >0.5cm between their measures, of which 28 of them had >2cm between their measures. Closer inspection of these pupils revealed that the majority had a difference of <5cm, and all were less than 8cm. No changes to data were made. At Wave 2 thirty individuals had a mean waist where the difference between the 2 measures used to calculate the mean was greater than 0.5cm but all were less 1.5cm and deemed to be acceptable. Differences between the hip measures were also checked. At Wave 1, 148 people had a difference between measures of >0.5cm, and 23 of them had differences >2cm. Of these, the majority had a difference of <4cm. At Wave 2, eight pupils had a difference between their measures of >0.5cm, but all were less than <0.9cm apart.

The difference between the hip and waist measurement for each individual at each Wave was calculated. At Wave 2, five pupils had waist measures which were greater than their hip measures. The difference ranged from 0.9cm to 4.8cm. These values were plausible and no changes were made.

Standard of living score

As previously described, the standard of living score could range from 0 to 19 items. It was decided that it was highly unlikely that any pupil could score 0 (as items such as bathroom/toilet were on the list). At Wave 1, one pupil reported no items, another only 1 item (the 1 item was a DVD player which seemed implausible). The next lowest score was 5. At Wave 2, 15 pupils (all boys) reported having 0 items, the next lowest score was 8. Those reporting improbably low scores (0 or 1) were recoded to missing.

Physical Activity

The physical activity measures were checked systematically. At Wave 2 the first check was to ensure that a pupil had not reported doing an activity an extreme number of times or for an extreme total time in the previous 7 days. The range of values reported was examined to help inform sensible cut-offs. It was decided that it would be pragmatic to have the same cut-offs for all activities (although it is acknowledged that it is more plausible for some activities to have been done for a greater number of times/longer length of time than others). Any pupil reporting >14hrs, or >14 sessions of an activity in the previous 7 days was recoded to missing for both the time and number of sessions variables. It was decided that an activity session had to have lasted at least 5 minutes and no more than 240 minutes (or that the average length of a session had to fall within these limits for a pupil who reported doing an activity more than once). Therefore any pupils who reported an activity session which had a mean length outside of these limits had both their time and number of sessions recoded to missing.

The time and number of session variables were then summed for all the activities in the list and checked for any extremes in these total variables. The total number of activity sessions allowed was 28, and the total length of time 1800 minutes (30 hours i.e. 4 hours per weekday plus 5 hours per weekend day). Where pupils had values greater than these for either measure, both were recoded to missing.

For the simpler Wave 1 physical activity measure, the total number of sessions was also set at 28 to match Wave 2. Pupils who reported more than this had their value recoded to missing.

2.2.2 Extent of Missing Data

2.2.2.1 DASH

Missing data are data that were intended to be collected but were not. In the case of DASH, missing survey data resulted from pupils not answering all of the questions in the survey (e.g. a pupil may have run out of time and not managed to complete it, or they may have chosen not to answer a particular item). Missing measurement data could have resulted from a pupil failing to turn up for the measurement session (the pupils usually completed their questionnaire in the first school period then had to return to have measurements taken later in the school day). It could also have been due to a lack of time to complete all measures (e.g. if the pupil turned up to the measurement session late) or a result of a pupil choosing not to have a particular measurement taken (e.g. a pupil may have consented to having their blood pressure taken but not to having their weight measured).

A further reason for missing measurement data is if a pupil was not identified as being from one of the main ethnic groups. As has been previously discussed, only those belonging to one of the main ethnic groups were invited to have measurements taken in Wave 2. The invitation cards were written in advance of our visit to the school, based on the ethnicity a pupil reported in Wave 1. During the school visit, the researchers attempted to identify any pupil who should have been invited to have measurements taken but had not been by checking whether the ethnicity they reported at Wave 2 made them eligible for measurements. Where this was the case, they were then invited to take part. However it is possible that some of these pupils were missed, resulting in missing data.

Every effort was taken to minimise missing DASH data, both questionnaire and measurement. Once a pupil finished their questionnaire, a survey assistant checked through it for any missing items. The pupil was then given the opportunity to complete any such items. Where a pupil ran out of time, their questionnaire was marked as unfinished and they were given the opportunity to complete it when they returned for their measurement session. If there was a lack of time to complete a pupil's measurements, or if a pupil failed to turn up to their measurement session, they were invited to attend another measurement session during our mop-up visit to that school.

Despite all efforts, missing data occurred. The proportion of data missing varied considerably between Waves and for different items. For the measurement data, proportions missing were higher at Wave 2 than Wave 1 with the exception of missing pubertal status data for boys (Table 2.10). The variables sex, age, and ethnicity had no missing data. In general, the proportion of missing questionnaire data was considerably lower for Wave 2 than Wave 1 (the pupils were older at Wave 2 and more able to complete the questionnaire within the allocated time) (Table 2.11). The physical activity items have notably higher proportions of missing values than the other variables at Wave 2; these questions in the questionnaire were probably the most complex to answer.

Table 2.10 Missingness of DASH Measurement Data

Variable group	Variable	% Missing	
		W1	W2
BMI	Height	2.29	9.23
	Weight	2.82	9.32
Waist/Hip	Waist circumference	2.44	9.11
	Hip circumference	2.41	9.14
Pubertal Stage	Girls' pubertal stage	12.60	9.59
	Boys' pubertal stage	21.39	10.56

Table 2.11 Missingness of DASH Questionnaire Data

Variable group	Variable	% Missing (n=3401)	
		Wave 1	Wave 2
Family SES	Overcrowded house	14.73	1.59
	Standard of living items (19 item score)	14.38	3.88
	Family own car/van	5.91	0.53
	Family have private garden	6.94	0.50
	Family type	3.91	0.88
	Mum employment	7.12	9.14
	Dad employment	8.00	6.70
Acculturation	Generational status	3.76	/
	Languages spoken at home	11.26	1.41
	Friends of different ethnicity	10.61	1.50
	Religious attendance	10.94	2.03
Pupil diet	Fruit and Vegetable consumption	14.38	0.79
	Breakfast frequency	9.56	/
Pupil physical activity	Number of different activities participated in	29.64	10.47
	Number of activity sessions per week	29.64	10.47
	Number of breathless activity sessions	/	10.64
	Total activity time in last 7 days	/	11.14
	Total breathless activity time in last 7 days	/	23.38
	Mode of Travel to school	/	1.03
	Mode of Travel from school	/	1.21
Pupil sedentary behaviour	Time spent on phone	/	0.59
	Time spent texting	/	0.74
	Time spent emailing	/	0.85
	Time spent watching TV	/	0.82
	Time spent playing computer games	/	0.82
	Time spent reading	/	0.65
	Hours asleep	/	1.94
Pupil smoking	Pupil smoking status	19.61	2.41
Parental behaviour	Mum smoking	6.91	4.68
	Dad smoking	7.12	4.79
	Mum overweight	6.59	1.44
	Dad overweight	5.82	1.53
Neighbourhood	Like area	14.55	1.15
	Feel safe in area during the day	14.76	1.26
	Feel safe in area at night	14.91	1.44
	Other people think it is a good area	15.23	1.62
School	Like teachers in general	22.49	/
	Have at least one teacher who is supportive	22.96	/

2.2.2.2 School Data

There were complete data on which school each pupil attended. As already discussed, all schools had complete school census and academic performance and absence data. Therefore, the only source of missing school data was the Ofsted reports (Table 2.12). One school had a Wave 2 Ofsted Report which did not include a measure of 'progress of learners with learning difficulties' or 'how well learners were guided and supported'.

Table 2.12 Number of schools with missing Ofsted data

	W 1	W2
Ofsted Report missing	15	9
Expenditure per pupil	15	/
How good is the overall personal development and well-being of the learners?	/	9
The extent of learners' spiritual, moral, social and cultural development	/	9
The extent to which learners adopt healthy lifestyles	/	9
How well learners with learning difficulties and disabilities make progress.	/	10
How well are learners cared for, guided and supported	/	10
How well learners enjoy their education	/	9

2.2.2.3 Neighbourhood Data

Missing neighbourhood data resulted from pupils/schools not reporting a residential postcode or reporting an inaccurate or incomplete postcode (pupils could only be linked to the neighbourhood statistics data via a valid postcode). Postcodes which did not match to an LSOA were checked and cleaned where appropriate (this mainly involved correcting data entry errors, often 'O' to '0'); this cleaning resulted in an extra 107 pupils having a valid postcode at Wave 1 and 16 at Wave 2. After data cleaning, the proportion missing a valid postcode was 19.6% (n=668) at Wave 1 and 5.23% (n=178) at Wave 2 (Table 2.13). Overall, over three quarters (75.8%) of the pupils had a valid postcode at both Waves, 4.6% had only a Wave 1 postcode, and 19.0% only a Wave 2 one. Only 23 pupils (0.68%) did not have a valid postcode at either Wave.

Table 2.13 Completeness of postcode data

	Wave 1		Wave 2		Both Waves	
	n[1]	%	n[1]	%	n[1]	%
Valid postcode (linked to LSOA)	2733	80.4	3223	94.5	2578	75.8
No valid postcode	668	19.6	178	5.23	23	0.68
of those:						
Missing	*558*	*83.5*	*83*	*46.6*	/	/
Invalid/incomplete	*110*	*16.5*	*95*	*53.4*	/	/

[1]Total n=3401

There was considerable residential stability in this population. Of those who reported a valid postcode at both Waves (n=2578), 74.2% (n=1913) had the same postcode at both Waves, 77.5% (n=1998) lived in the same LSOA at both Waves, and 80.4% (n=2074) lived in the same MSOA (Middle Super Output Area - MSOAs are groups of LSOAs and have a minimum population of 5000 and a mean of 7200). Of those who had changed address (n=665), 12.8% were still in the same LSOA and almost a quarter (24.2%) were still living in the same MSOA. Overall, over 80% of the children who reported valid postcodes at both Waves were living in the same MSOA at both time points. This relatively high level of residential stability is perhaps unsurprising given that all of the pupils were attending the same school at both Waves (it is likely that if a child had moved far from their Wave 1 address that they would be attending a different secondary school by Wave 2 and would have been lost from the study).

Given the high degree of residential stability among those who reported valid postcodes, and the fact that all of the children in this sample attended the same school at both Waves, it was decided that if a pupil was missing postcode data for only one Wave, then their LSOA from the other Wave would be imputed. By imputing the residential neighbourhood data in this way, only 23 pupils (who did not have valid postcode data at either Wave) had missing neighbourhood data.

2.2.3 Imputation

Missing data were imputed using the SAS software IVEware (Imputation and Variance Estimation Software). This software can perform either single or multiple imputations using a sequential regression imputation method (Raghunathan et al., 2002). This software was chosen because it enabled restrictions and boundaries to be placed on the values which could be imputed for multiple variables. The neighbourhood data and individual-level data files were merged prior to imputation. This allowed missing neighbourhood data to be imputed based on a pupil’s individual characteristics. This dataset was then stratified by gender; this allowed the relationship between different variables to differ by sex in the imputations. Previous analysis of the DASH data has shown that there are gender differences in the relationship between body size and ethnicity and other covariates (Harding et al., 2008c, Harding et al., 2008b).

As the imputation procedure assumes a normal distribution for continuous variables, all continuous variables were checked for normality by assessing skewness and kurtosis statistics (a normal curve has a skewness of 0 and a kurtosis of 3), and visually by plotting a histogram of the variable with a normal curve super-imposed. Where a distribution was found to be non-normal, various transformations were tried including natural log, inverse, and square root. The most appropriate transformation was used in the imputation. An example of a continuous variable's distribution before and after transformation, along with corresponding skewness and kurtosis figures, is shown in Figure 2.3; it can be seen that boys' weight at Wave 1 had a more normal distribution after being log transformed. Table 2.14 summarises the continuous variables which were transformed prior to imputation. Several of the physical activity variables were treated as counts with a Poisson distribution in the imputation: total number of activity sessions (both Waves), total number of breathless activity sessions (Wave 2) and total number of different activities (both Waves).

Figure 2.3 Distribution of Boys Wave 1 weight measures before and after transformation
(i) Untransformed **(ii) Natural Log**

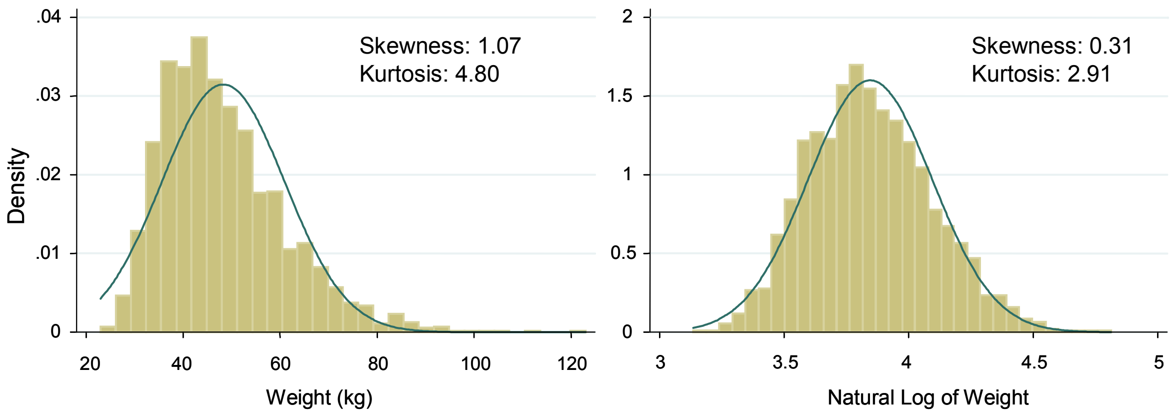


Table 2.14 Transformation of continuous variables prior to imputation

Variable[1]	Transformation[2]
Wave 1 weight	Natural log
Wave 2 weight	Natural log
Wave 1 waist	Natural log
Wave 2 waist	Inverse
Wave 1 hip	Natural log
Wave 2 hip	Inverse

[1]Continuous variables not listed here were not transformed

[2]Same transformation was performed for both boys and girls

Several variables needed to have restrictions and boundaries placed on them in terms of what values could be imputed (Table 2.15). The number of iterations (number of cycles) was set to 100. We made the pragmatic decision to impute only a single data set. With the neighbourhood land use variables and neighbourhood ethnic density, we had to reach a compromise between transformation and bounding. Originally we had hoped to restrict the imputation so that totals of these variables to add up to 100%. However the imputation failed due to the circularity of these restrictions. As an alternative, a decision was made to impute the variables without restrictions, then to scale the total to 100. So for example, if the total of all of the ethnic densities added up to 105% then they would all be rescaled so that the total was 100.

Table 2.15 Restrictions placed on variables during imputation

Variable description[1]	Restriction
Physical measures	
Pubertal stage	Wave 2 could not be earlier stage than Wave 1
Height	Wave 1 height <= Wave 2 height
Family SES	
Standard of living 19 item score (wave 1)	<=19
Standard of living 19 item score (wave 2)	<=19
Dad employment status	Has to be coded 'not resident' if dad not resident
Mum employment status	Has to be coded 'not resident' if mum not resident
Physical Activity	
Total number of activity sessions	Must be >= total number of different activities
Total no. breathless activity sessions (Wave 2)	<= total number of activity sessions
Total no. of minutes spent in activity (Wave 2)	Must be minimum of 5 times the total no. of activity sessions; must =0 if total no of activity sessions =0.
Total no. of breathless minutes (Wave 2)	<=total no. of minutes, must =0 if total no of activity sessions =0.
Parental behaviour	
Mum overweight	Has to be coded 'not resident' if mum not resident
Dad overweight	Has to be coded 'not resident' if dad not resident
Mum smoking	Has to be coded 'not resident' if mum not resident
Dad smoking	Has to be coded 'not resident' if dad not resident

[1]Variables not listed had no restrictions placed on them

The incomplete school data (Ofsted) were imputed separately (without using individual characteristics) using a similar approach. This dataset consisted only of the school data (DCSF, Census and Ofsted) and the schools' neighbourhood data. The only continuous variable to be imputed, school expenditure per pupil, was log transformed. No restrictions or boundaries were necessary.

2.3 Statistical Analysis

Multilevel modelling (MLM) was used to examine the association between body size and school and neighbourhood environments. MLM is a statistical technique which can be used to investigate contextual influences on health. In the first part of this section an overview of MLM is given; this includes a description of clustered data and hierarchical and cross-classified structures (including a description of the DASH data structure); an explanation of partitioning of variance in MLM; and finally an overview of the fixed and random effects of which a multilevel model is comprised. The second part of this section details both the descriptive analysis and the multi-level modelling undertaken.

2.3.1 Overview of multilevel modelling

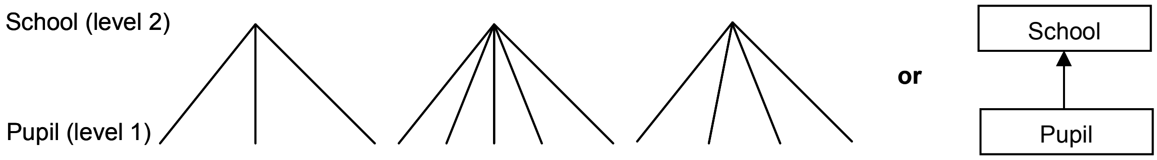
Most statistical methods assume that measures on individuals in a sample are independent of one another i.e. 'the value of one observation is not influenced by the value of another' (Kirkwood and Sterne, 2003, p355). However there are times when data are clustered and measures are not independent. Clustered data can arise from samples being grouped; examples include children grouped in schools, or residents in neighbourhoods. Longitudinal studies with repeated measures also result in clustered data, with observations being grouped within individuals (Steele, 2008). If the observations within a cluster are more similar to each other than they are to observations in the wider sample, then the assumption of independence between observations is violated. Using standard regression techniques to analyse such data results in biased estimates (Merlo et al., 2005a).

MLM is a statistical technique which accounts for clustering in data, producing results which are not biased due to the assumption of independence being violated; it deals with the 'statistical nuisance' that clustering causes (Merlo et al., 2005a). In addition to this, MLM can be used to explore the impact of context on health. This is because it is often the clustering that is of intrinsic interest and not just something that has to be adjusted for. Merlo et al. (2005a) emphasise the link between 'the statistical concept of clustering and the social epidemiological idea of contextual phenomenon'. They therefore promote MLM as a technique to investigate contextual influences on health.

2.3.1.1 Structure of clustered data

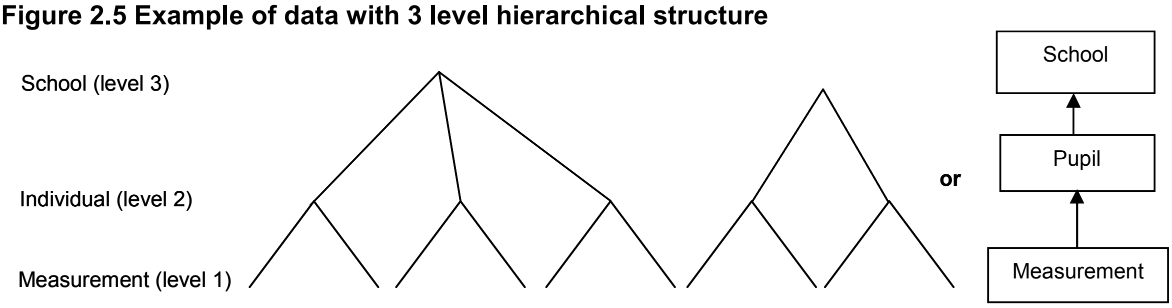
Clustered data can have a hierarchical structure. An example of a 2-level hierarchy is pupils clustered within schools (Figure 2.1). The standard notation is to describe the lowest level (in this example, pupils) as 'level 1' and the higher level (schools) as 'level 2' (Rasbash et al., 2009). This figure is therefore showing 3 schools; the first has 3 individuals in it, the second has 5 individuals, and the third 4 individuals. MLM does not require there to be a balanced sample; there can be a different number of observations in each cluster (Merlo, 2005).

Figure 2.4 Example of data with 2 level hierarchical structure



In longitudinal studies such as DASH, the measurements are clustered within pupils and are therefore the lowest level in the model (Steele, 2008). An example of a 3-level hierarchy is measurements (level 1) clustered within pupils (level 2), who in turn are clustered within schools (level 3) (Figure 2.5). In the example shown, each of the five individuals has had 2 measurements taken (e.g. their weight on two different occasions). Three of these pupils belong to one school and the other two individuals to another school.

Figure 2.5 Example of data with 3 level hierarchical structure

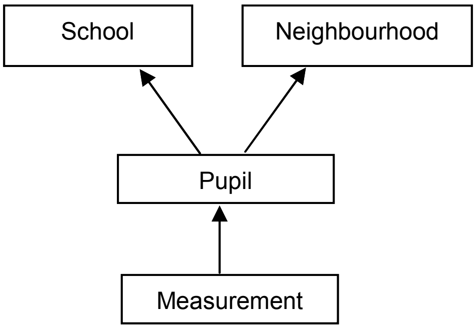


Often data do not have the strict hierarchical structure described above. Schools and neighbourhoods are not clustered within one another; not all children who live in the same neighbourhood attend the same school, and not all children in the same school live in the same neighbourhood (Rasbash and Goldstein, 1994). Traditional models of school or neighbourhood effects have been two-level models with individuals (at level 1) clustered within either neighbourhoods or schools (level 2) (Leckie, 2009). However the pupils are exposed to both school and neighbourhood contexts; these contexts do not exist in isolation of each other. By analysing the effect of the school context without taking into account the neighbourhood environment, effects that are actually due to the neighbourhood may be wrongly attributed to the school and vice versa.

The schools and neighbourhoods are said to form a cross-classification (Fielding and Goldstein, 2006, Goldstein, 1994).

Figure 2.6 shows the structure of the DASH data; schools and neighbourhoods form a cross-classification at level 3, within which the pupils (level 2) and their measurements (level 1) are clustered.

Figure 2.6 Cross-classified 3-level hierarchical structure of the DASH data



An additional complexity of the DASH data structure is that pupils could belong to more than one neighbourhood (that is, they may have been living in one neighbourhood at Wave 1 and in another at Wave 2). As the measurement occasions were clustered within neighbourhoods, this was another cross-classification rather than an example of multiple-membership (multiple-membership refers to when an observation can belong to more than one upper level classification e.g. an individual could work in 2 different places) (Fielding and Goldstein, 2006, Leckie, 2009). In DASH a single measurement could not belong to two neighbourhoods as it existed at only one point in time (whereas a pupil could belong to two neighbourhoods as they could have moved). Only pupils who attended the same school at both waves were included in the sample, therefore no pupil attended more than one school.

2.3.1.2 Partitioning of variance

A key feature of MLM is that it provides measures of *variation* in an outcome in addition to measures of *association*, such as the regression coefficients given by linear regression models (Merlo et al., 2005a). MLM allows variance in an outcome to be partitioned between the different levels in the hierarchy. In a 2-level hierarchical model of individuals within schools for example, MLM techniques can determine how much of the variance in the outcome is due to differences between individuals and how much is due to differences between schools.

The equation for an empty multilevel model is given (Equation 2.2) (this model is termed ‘empty’ as it does not contain any explanatory variables). This is a 2-level model with individuals at level 1 and schools at level 2.

Equation 2.2 2-level model with no explanatory variables

$$y_{ij} = \beta_0 + u_j + e_{ij}$$

y_{ij} is the outcome measurement for individual ‘i’ in school ‘j’.

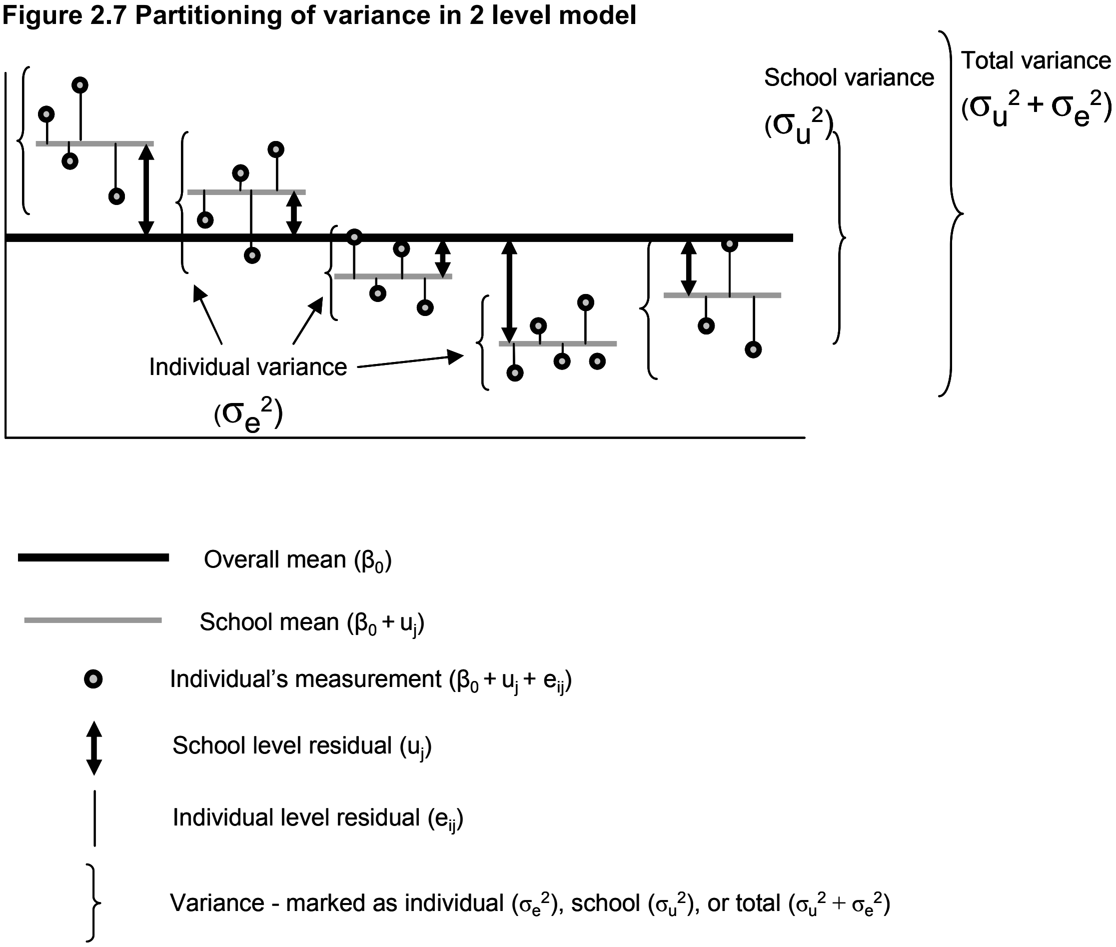
β_0 is the intercept (giving the mean measurement value for the sample)

u_j is the school residual (or ‘school effect’). This is the difference between the sample mean (β_0) and the mean of school j.

e_{ij} is the individual residual; the difference between the school’s mean and the individual’s value.

If BMI is the outcome (y), then an individual’s BMI measurement is given by the mean BMI of the sample plus the school residual (i.e. the difference between the mean BMI of the sample and the mean BMI of the school the individual attends), plus the individual residual (i.e. the difference between the school’s mean BMI and the BMI of the individual). This is illustrated in Figure 2.7 (modified from Merlo et al., 2005a). In this diagram there are 5 schools and 20 individuals. There are between 3 and 5 individuals in each school. The black line is the overall mean of the measures on the 20 individuals (e.g. this could be their mean BMI). There are 5 grey lines, each representing the mean measure of the individuals in that school. So 2 of the schools have a mean BMI greater than the sample mean, and the other 3 schools have a mean less than the sample mean. The difference between each school’s mean and the sample mean is called the school residual. Within each school, some of the pupils have measurements greater than the school mean and some less than the school mean. The difference between each individual’s measurement and their school’s mean is known as the individual residual. Figure 2.7 also shows the variances. Variance is a measure of how far each observation deviates from the mean (Kirkwood and Sterne, 2003). If the variance is small, the observations all lie close to the mean; if the variance is large then there are observations which are much higher and lower than the mean value. In MLM, the total variance is a measure of the spread of the individual observations around the overall mean. The school variance is a measure of the spread of school means around the overall mean. The individual variance is a measure of the spread of individual measures around each school's mean. The school variance and individual variance added together give the total variance. Hence it is possible to calculate what proportion of the total variance is at the school or individual level.

Figure 2.7 Partitioning of variance in 2 level model



The Intraclass Correlation Coefficient (ICC)

The ICC gives the proportion of the total variance which is at the upper level i.e. variance at upper level divided by total variance (Equation 2.3).

Equation 2.3 Calculation of Intraclass Correlation Coefficient

$$ICC = \sigma_u^2 / (\sigma_u^2 + \sigma_e^2)$$

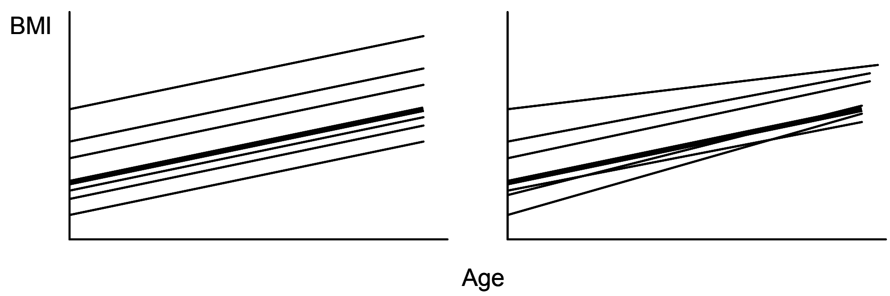
The ICC always takes a value between 0 and 1. An ICC of 1 means that all observations within a cluster are identical; all of the variation in the outcome is at the upper level (Merlo et al., 2005a). That means that all of the variation in an outcome is between clusters; once cluster has been accounted for there is no further variation between the individual observations. A variance at the upper level of 0, and hence an ICC of 0, means that there is no more variation between the clusters than would be expected due to chance. An ICC value of 0.05, for example, means that 5% of the variance in the outcome is at the upper level. An important point is that a small ICC does not imply that there is no contextual effect; it is possible for there to be a significant contextual relationship (e.g. for a school-level characteristic to be related to the outcome) even when the variance at the upper level is not statistically significant (Merlo et al., 2005a).

2.3.1.3 Fixed effects and random effects

Multilevel models include both fixed and random effects. 'Fixed effects' are the regression coefficients of each of the covariates in the model (as would be found in a standard linear regression model). Fixed effects therefore model the average effect of an independent variable on the dependent variable (Merlo et al., 2005c). Random effects model the residuals (for example school residuals).

In a random intercept model the mean value in each cluster differs but the relationship between the covariate(s) and the outcome is the same in all clusters. Therefore if this was represented graphically, each of the clusters would have it's own intercept (random part of model) but the lines would be parallel as the regression coefficients would be the same for each cluster (fixed part of model) (Figure 2.8). In a random slope model, the gradients of the lines as well as the intercepts can differ by cluster.

Figure 2.8 Illustration of random intercept and slope models
(a) Random Intercept **(b) Random Slope**



In the examples shown in Figure 2.8, the bold lines represent the overall mean relationship between age and BMI in the sample. In both models, BMI gradually increases with increasing age. Each of the thin lines represents a school. Each of these lines has its own intercept, showing that mean BMI differs between schools. In the random intercept model all of the lines have the same gradient; the relationship between age and BMI is the same in all schools. In addition, the difference in mean BMI between schools is the same at all ages. In contrast, in the random slope model the relationship between age and BMI is not constant across schools. In some schools, for each unit increase in age, the corresponding increase in BMI is greater than in others. Furthermore, the difference in mean BMI between schools differs depending on the pupils' age (e.g. in this example the difference between the schools declines with increasing age). The ICC for the outcome (BMI) now depends on the value of the covariate (age). That is, the ICC at younger ages will differ from the ICC at older ages.

The models can be represented by the equations shown (Equation 2.4). The notation is the same as was seen for the null model previously (Equation 2.2). An independent variable 'x' (in this case, age) has been added. In the random intercept model (Equation 2.4a), the part of the model in parenthesis is the fixed part of the model; it is the equation for the bold line in the graph where β_0 is the intercept and β_1 the regression coefficient for age. The school effect (u_j) is the term which, when added to the mean intercept (β_0), gives the specific intercept for that school. β_1 is constant for all schools, hence the parallel lines. In the random slope model, u_{0j} is the school-specific residual for the intercept and u_{1j} is the school-specific slope residual.

Equation 2.4 Multilevel Model Equations
(a) Random intercept model

$$y_{ij} = \underbrace{(\beta_0 + \beta_1 X_{ij})}_{\text{Fixed part}} + \underbrace{u_j + e_{ij}}_{\text{Random part}}$$

(b) Random slope model

$$y_{ij} = \underbrace{(\beta_0 + \beta_1 X_{ij})}_{\text{Fixed part}} + \underbrace{(u_{0j} + u_{1j} X_{ij}) + e_{ij}}_{\text{Random part}}$$

2.3.1.4 Modelling data with a cross-classified structure

As was briefly discussed in Section 2.3.1.1, the DASH data do not have a strictly hierarchical structure. It is important to model such data appropriately; 'the consequences of ignoring an important cross-classification are similar to those of ignoring an important hierarchical classification' (Rasbash et al., 2009). Not specifying that a model is cross classified results in the number of clusters being artificially inflated. For example, if there are 10 children living in a neighbourhood, and they attend three different schools between them, then this will be treated as though these children live in three separate neighbourhoods; it will essentially force neighbourhood to be clustered within school. Cross-classified random-effects models explicitly acknowledge the non-hierarchical structure of the data (Leckie, 2009). Therefore variance in the outcome variable will be correctly partitioned between the different levels in the model.

2.3.2 Analysis

Stata (Version 10.0) was used for all descriptive analyses. All multilevel analyses were performed using either Stata or MLwiN (Version 2.16). For longitudinal analyses it was necessary to convert the DASH dataset from short to long format (an example is shown for two pupils in Table 2.16). All analyses were stratified by gender.

Table 2.16 Short and long format data example
(a) Short format

Student ID	Wave 1 Age	Wave 2 Age	Wave 1 BMI	Wave 2 BMI
21000	12.3	15.2	16.3	19.0
23021	11.1	14.9	21.2	23.5

(b) Long format

Student ID	Wave	Age	BMI
21000	1	12.3	16.3
	2	15.2	19.0
23021	1	11.1	21.2
	2	14.9	23.5

2.3.2.1 Descriptive analysis

Overall and ethnic specific trends in body size

The first stage of analysis involved examining each of the anthropometric measures in detail: height, weight, BMI, waist circumference, hip circumference, WHR, plus the SD scores of height, weight, BMI and waist. Levels of overweight and obesity in the sample were also examined. The aim of this descriptive work was to gain a broad overview of ethnic and gender differences in body size trends in adolescence.

For each of the anthropometric measures, trends in observed values by gender and then by ethnic group were investigated. This involved plotting the mean values (or proportions for overweight/obesity) of the various measures by age and sex in order to determine how they were changing between the ages of 12yrs and 16yrs. This was followed by cross-sectional linear regression analysis which examined the statistical significance of ethnic differences in each of the continuous outcomes at 11-13yrs (Wave 1) and 14-16yrs (Wave 2), and the impact of adjustment for pubertal status and height SDS on these ethnic differences. The main objectives of these exploratory analyses were to determine:

- whether there were statistically significant ethnic differences for any of the measures at either 11-13 years or 14-16 years.
- whether the magnitude of any ethnic differences changed between 11-13 years and 14-16 years.
- whether height and pubertal status, both key correlates of body size measures, attenuated the ethnic differences.

Further descriptive analysis examined the impact of pubertal status on body size and if this differed by ethnic group and age. Mean body size measures by sex, ethnicity and pubertal status were calculated for two age groups (11-13yrs and 14-16yrs). (It was only possible to compare two age groups as numbers often became very small in the mid/early puberty groups if smaller ages categories were used.)

The final piece of descriptive analysis explored how the different body size measures related to one another and how this differed by ethnicity and sex. Firstly, sex and ethnic group specific correlation coefficients were calculated for the relationship between: BMI SDS and Waist SDS; Height SDS and Waist SDS; and Height SDS and BMI SDS. Secondly, categorical variables were derived for BMI SD and Waist SD scores (<-1.5SD; -1.5SD to <0SD; >=0SD to <1.5SD; ≥1.5SD); cross-tabulations between these variables were then performed. The results of the descriptive analyses of the body size measures are presented in Chapter 3.

School, neighbourhood, individual and family covariates

For all of the covariates (i.e. non outcome variables) summary statistics are presented by gender, age (11-13yrs and 14-16yrs), and ethnicity; usually these are percentages and 95% confidence intervals. Means are presented for continuous measures. Results are presented in the first section in the appropriate findings chapter (school covariates in Chapter 4, neighbourhood covariates in Chapter 5 and individual and family covariates in Chapter 6). In all cases, proportions are taken to be significantly different to the White UK group, or to differ significantly by age within an ethnic group, if the 95% confidence intervals do not overlap (Julious, 2004).

2.3.2.2 Variance in BMI SDS and Waist SDS at school and neighbourhood level

Multilevel linear regression models were used to determine the proportion of variance in BMI SDS and Waist SDS at the school and/or neighbourhood level. Models were built with school only at the upper level, neighbourhood only, and a cross-classification of neighbourhood and school. A summary of the model types and the estimation procedure used for each is given below.

School model

A three level model with measurement at level 1, pupil at level 2, and school at level 3. This model was built in Stata (Version 10); the 'xtmixed' command was used to fit linear multilevel models using restricted maximum likelihood (REML) estimation.

Neighbourhood model

A three level model with measurement at level 1, pupil at level 2, and neighbourhood (LSOA) at level 3. This was a cross-classified model as individuals could belong to a different LSOA at each Wave. Therefore these models were fitted in MLwiN using Markov chain Monte Carlo (MCMC) based algorithms (Browne, 2009).

School and neighbourhood model

A three level model with measurements (level 1) clustered within pupils (level 2) who were in turn clustered within a cross-classification of schools and neighbourhoods at level 3. Again, due to the cross classifications, this was estimated using MCMC in MLwiN.

The aim of the three types of model was to determine:

- The relative importance of the school and neighbourhood contexts.
- Whether including both school and neighbourhood contexts in the same model changed the results obtained when they were examined individually.
- To check that the different estimation procedures were producing comparable results.
- To inform which of the three types of model should be used to model trends in BMI SDS and Waist SDS.

The proportion of variance at the upper level (whether that be neighbourhood, school, or both) was calculated with only age in the model. These 'null' models were to determine how much variation there was between neighbourhoods and schools before accounting for any covariates.

Pubertal status, height (SDS) and ethnicity were then added to the models (the models adjusting for age, pubertal status, height SDS and ethnicity are referred to hereafter as 'baseline' models; the development of these baseline models is described in detail in Section 2.3.2.4). Null and baseline models were compared to ensure that conclusions made from the null model (with regards to the aims listed above) still held when these key correlates of BMI SDS and Waist SDS were added to the model.

Based on the results of this analysis (presented in Chapter 4) it was decided that the data would be modelled with only school at level 3, with the neighbourhood characteristics being added as individual level covariates. This meant that Stata could be used for all analyses as there would be no cross-classifications in the data structure. Being able to analyse the data in Stata had several practical advantages; compared to MLwiN models are considerably quicker to build, easier to store, and simple to edit. Furthermore, as the models including only school had a simple hierarchical structure they were much quicker to run than the cross-classified models including neighbourhood. Restricted maximum likelihood models in MLwiN are generally very quick to converge, however the MCMC estimation technique that is necessary due to the cross-classified nature of the data is considerably slower. The models with a cross-classification between neighbourhoods and schools were slower to run than those with only neighbourhoods.

The practical advantages of Stata were deemed to be important given the large number of models which were to be run. It was not felt that the small amount of variation between neighbourhoods justified the greatly increased time that analysis would take in order to include neighbourhood as a level. It is important to note that as MLwiN is a specialist multi-level modelling package it does have advantages over Stata, which is a more general statistical software. MLwiN was therefore used to produce some graphs, which were either not as easy or not possible to create in Stata.

2.3.2.3 Ethnic differences in variance

The models described so far considered the proportion of the variance in the outcomes which was between neighbourhoods and between schools for the whole sample (stratified by sex). It was important to check that the conclusions reached from analysing the whole sample (in particular the assumption that modelling with only school at level 3 would be adequate for the main analyses) held for each of the ethnic groups. For example, it could be that for one ethnic group the neighbourhood context was more important than for the others. In order to determine if this was the case, models were run with random effects for each of the ethnic groups at the measurement and individual level. These models also gave information on how the amount of variation between measurements (within individual) and between individuals (within schools/neighbourhoods) varied by ethnic group.

The random slopes models were run in MLwiN; models with school at level 3 were estimated using maximum restricted likelihood; models including neighbourhood with MCMC. A random effect for ethnicity at the contextual level was not fitted; therefore the amount of variation at the school and neighbourhood level was the same for every ethnic group (the size of each ethnic group in the sample was not adequate to enable a random effect at the contextual level to be estimated). Models were run with only school at level 3, only neighbourhood at level 3, and with a cross-classification of schools and neighbourhoods at level 3. This was to ensure that any conclusions reached remained valid when the school and neighbourhood contexts were considered simultaneously. Results are presented in Chapter 4.

2.3.2.4 Development of the baseline models

Baseline models were developed for all of the body size outcomes (weight, height, BMI, waist, hip, WHR, and SD scores where relevant). Based on the results from the cross-sectional analyses, it was decided that age, ethnicity, height (SDS) and pubertal status should be included in the baseline models for each of the outcomes; the exception being models with Height and Height SDS as outcomes which adjusted for age, ethnicity and pubertal status only.

For ease of interpretation and prediction of values from the models, a continuous age variable with age measured in 6 monthly steps rather than fully continuous was used. This new variable was created by rounding the continuous age variable to the nearest 6 months. With this new age variable, all of the pupils were aged between 11yrs and 16.5yrs (except for one boy and one girl classified as 17 who were aged 16.83yrs and 16.87yrs respectively). There were few pupils classified as being 11yrs (boys n=3, girls n=1) or 16.5yrs (boys n=51, girls n=40). After checking that their BMIs, heights, and weights were not significantly different, it was decided to combine the 11 category with 11.5, and the 16.5 and 17 categories with 16. The variable was then centred on 12yrs so that the models would have a meaningful intercept. This new 6 month age variable is described in Table 2.17 (note that as the data are in long format the sample size is effectively doubled as measurements are now the lowest level unit rather than pupils). Initial models were run first with age in this 6 month format, and then repeated using age in its fully continuous form. Results were checked to ensure they were consistent; they were and so all models used the simplified 6 month variable. Age squared (age^2) and age cubed (age^3) variables were derived from the centred 6-month age variable to enable a non-linear relationship between age and the outcomes to be modelled.

Table 2.17 Description of 6-month age variable by gender

Age category (yrs)	*Code (centred on 12yrs)*	***Boys*** *N (%)*	*Mean age (95%CI)*	***Girls*** *N (%)*	*Mean age (95%CI)*
11.5	-0.5	159 (4.3)	11.59 (11.57-11.61)	146 (4.7)	11.61 (11.60-11.63)
12	0	437 (11.9)	12.01 (12.00-12.02)	389 (12.4)	12.00 (11.98-12.01)
12.5	0.5	452 (12.3)	12.49 (12.48-12.50)	370 (11.8)	12.49 (12.48-12.51)
13	1.0	461 (12.6)	13.00 (12.99-13.01)	376 (12.0)	13.00 (12.98-13.01)
13.5	1.5	297 (8.1)	13.46 (13.44-13.47)	263 (8.4)	13.47 (13.45-13.48)
14	2.0	100 (2.7)	14.06 (14.02-14.09)	75 (2.4)	14.08 (14.04-14.12)
14.5	2.5	434 (11.8)	14.50 (14.49-14.51)	353 (11.3)	14.51 (14.50-14.53)
15	3.0	456 (12.4)	15.01 (14.99-15.02)	406 (13.0)	15.00 (14.99-15.02)
15.5	3.5	437 (11.9)	15.50 (15.49-15.51)	403 (12.9)	15.50 (15.48-15.51)
16	4.0	441 (12.0)	16.01 (16.00-16.03)	347 (11.1)	16.03 (16.01-16.05)
All ages		3674 (100)	13.91 (13.86-13.96)	3128 (100)	13.90 (13.85-13.95)

Baseline models were built systematically, with the same approach being used for every outcome (Table 2.18). Model 1 included age, pubertal status, height SDS and ethnicity; these variables were automatically included irrespective of their significance level as they are key correlates of BMI, height and weight. Next, age^2 was added (model 2). If age^2 was significant ($p<0.05$) then age^3 was also added (model 3). At this stage, either model 1, 2 or 3 was chosen dependent on whether the squared and cubed age terms were significant or not.

To the chosen model (1, 2 or 3), interaction terms were then added (only one interaction at a time was included). If none of the interaction terms was statistically significant ($p<0.05$) then the final model was either Model 1, 2 or 3 depending on which age terms were significant. If one interaction term was significant then the final model is Model 1, 2 or 3 plus the significant interaction term.

If more than one of the interaction terms was significant, all of the significant interactions were entered simultaneously into the model to determine whether they remained independently significant. Non-significant interaction terms were then removed. Where all interactions become insignificant, any interaction between an age term and ethnicity was prioritised. After this, if there were several other interactions then the least significant (highest p-value) was removed and the remaining interactions assessed. By this process of elimination the final model was reached. The variables and interactions in the baseline model for each outcome are summarised in Table 2.19.

Table 2.18 Modelling strategy to produce baseline models

Model	Description of variables in model (* = interaction)
1	Age (6 month continuous), Pubertal Status (late v. early/mid), Height (SDS), Ethnicity
2	Model 1 + Age^2
3	Model 2 + Age^3
Choice of either 1, 2 or 3	
4	Chosen model + Age*Ethnicity
5	Chosen model + Age^2*Ethnicity (if Age^2 in chosen model)
6	Chosen model + Age^3*Ethnicity (if Age^3 in chosen model)
7	Chosen model + Ethnicity*Pubertal Status
8	Chosen model + Ethnicity*Height
9	Chosen model + Pubertal Status*Height
10	Chosen model + Pubertal Status*Age
11	Chosen model + combinations of significant interactions
Selection of final model	

Table 2.19 Description of final baseline models

Outcome		Variables/Interactions in Final Baseline Model (* = interaction)
Height	Boys	ethnicity*age, age^2, age^3, pubertal status
	Girls	ethnicity*age, ethnicity*age^2, pubertal status*age
Height SDS	Boys	ethnicity*age, ethnicity*age^3, age^2, pubertal status
	Girls	ethnicity*age, ethnicity*age^2, pubertal status*age, age^3
Weight	Boys	ethnicity*age, pubertal status*age, pubertal status*height SDS, age^2, age^3
	Girls	ethnicity*age, pubertal status*age, age^2, height SDS
Weight SDS	Boys	ethnicity*age, pubertal status, height SDS
	Girls	ethnicity*age, pubertal status*age, age^2, height SDS
BMI	Boys	ethnicity*age, age^2, height SDS, pubertal status
	Girls	ethnicity*age, age^2, height SDS, pubertal status
BMI SDS	Boys	ethnicity*age, pubertal status*age, age^2, height SDS
	Girls	ethnicity*age, age^2, height SDS, pubertal status
Waist	Boys	ethnicity*age, age^2, age^3, pubertal status, height SDS
	Girls	ethnicity, age, age^2, age^3, pubertal status*age, height SDS
Waist SDS	Boys	ethnicity*age, pubertal status*height SDS, age^2, age^3
	Girls	ethnicity*age, ethnicity* age^2, age^3, height SDS, pubertal status
Hip	Boys	ethnicity*age, age^2, age^3, pubertal status, height SDS
	Girls	ethnicity, pubertal status*height SDS, age, age^2, age^3
WHR	Boys	ethnicity*age, age^2, pubertal status, height SDS
	Girls	ethnicity*age, ethnicity*age^2, pubertal status*height SDS, pubertal status*age

Due to the complexity of the models, it was decided to present predicted mean values from the models rather than coefficients. In Chapter 3, line graphs of predicted values from both the null and baseline models are presented for each outcome. These show ethnic specific trends in body size between the ages of 11.5 and 16yrs and the impact on these trends of adjustment for pubertal status and height.

2.3.2.5 The association between individual and contextual characteristics and body size (BMI SDS and Waist SDS)

In the next stage of the analysis, the association between school, neighbourhood, individual and family characteristics and body size was examined. For these analyses only two outcomes were considered; BMI SDS and Waist SDS. Each variable was added individually to the baseline model and its significance in the model and impact on variance at each level of the model were assessed. Models were then refitted with an interaction term between ethnicity and the variable being assessed; this was to determine whether the association between the given variable and BMI SDS differed by ethnic group. Where this interaction was significant ($p<0.05$), models stratified by ethnicity were built to further examine ethnic differences in the association. Results are presented for the school characteristics in Chapter 4, the neighbourhood characteristics in Chapter 5 and the individual and family characteristics in Chapter 6.

2.3.2.6 The impact of individual, family, neighbourhood and school on ethnic differences in body size (BMI SDS and Waist SDS)

The final step of the analysis was to build fully adjusted models which included school, neighbourhood, individual and family covariates. The variables to be included in these final models were selected based on their theoretical importance and the results of the models which assessed each variable's significance independently. The selected variables are summarised at the end of each findings chapter. The aim was to determine whether there were school or neighbourhood effects on body size once individual and family characteristics had been controlled for. Similarly these final models revealed whether adjustment for contextual factors affected any of the relationships between individual and family factors and body size. Finally, whether ethnic differences were explained by the individual, family, neighbourhood and school characteristics was assessed.

The final models were developed in a systematic way (Table 2.20). The actual variables included are described in Table 7.1 in Chapter 7. To the baseline model, family-level SES was added first, followed by measures of acculturation. Individual (i.e. pupil behaviour) factors were added next, followed by parental factors. Neighbourhood characteristics were then included; first subjective measures then objective. To this model which included individual, family, and school variables (Model 6), school level variables were added. Initially only one or two school-level variables were added at a time to the model adjusting for individual, family, and neighbourhood characteristics. This was because the number of upper level variables that can be included in a multilevel model is dependent on the number of upper level units (in this case schools). A general rule of thumb is for only one upper level variable to be included for every 10 upper level units. Adding too many upper level variables could result in a model failing to converge (i.e. reach a solution). Therefore models which included school level characteristics were then assessed to determine if the school characteristics improved the fit of the model.

A 'final model' was selected for BMI SDS and Waist SDS for the boys and girls. The four models chosen were considered to be the most theoretically and statistically appropriate. Interactions between covariates were then tested. The results of these models are presented as figures in Chapter 7 (in an analogous way to the results of the baseline models in Chapter 3). This allows a direct comparison of the impact of adjustment for a range of factors on ethnic differences in body size trends in adolescence.

Table 2.20 Model Building Steps

Model	Variables Included
Baseline	Age, height, pubertal status, ethnicity
Models 1-6 include individual, family, and neighbourhood variables	
1	Baseline + family SES
2	Model 1 + Acculturation
3	Model 2 + Individual behaviour
4	Model 3 + Parental factors
5	Model 4 + Subjective neighbourhood
6	Model 5 + Objective neighbourhood
Models 7+ include school level variables	
7	Model 6 + school variable A
8	Model 6 + school variable B
9	Model 6 + school variable C
Etc.	Model 6 + ………

2.3.2.7 The impact of individual, family, neighbourhood and school on ethnic differences in overweight and obesity

Although the focus of this thesis is on continuous measures of body size (BMI SDS and Waist SDS), it was of interest to determine whether adjustment for the range of characteristics could explain any of the ethnic differences in overweight and obesity, and whether factors significantly associated with BMI SDS and/or Waist SDS were also associated with overweight/obesity.

A binary weight status variable was derived; normal weight versus overweight/obese [with weight status based on International Obesity Task Force (IOTF) definitions (Pan and Cole, 2008)]. As it is more difficult to fit multilevel models with binary as opposed to linear outcomes, we decided that the overweight/obesity analysis would be modelled with only two levels (level 1 - measurement, level 2 - individual). Therefore both school and neighbourhood variables were entered into the models as individual-level covariates. This pragmatic decision to have only a 2 level model allowed analysis to be performed in Stata using the ‘xtlogit’ command. The exclusion of school and neighbourhood as levels in the model is justified given the very small amount of variance in body size at the contextual level.

The variables included in the final models for BMI SDS were used in the logistic multilevel model for weight status. The impact of individual, family, school and neighbourhood characteristics on overweight/obesity status and ethnic differences in overweight/obesity were assessed. Results are presented in Chapter 7.

3 Anthropometry

In this chapter ethnic and sex differences in body size, and how these change with age, are described. The following anthropometric measures were examined: height, weight, body mass index (BMI), waist circumference, hip circumference, and waist-hip ratio (WHR). The standard deviation scores (SDS) of height, weight, BMI and waist were also investigated; these were based on the 1990 Growth Reference population [more details are given in the Methods (Chapter 2)]. Ethnic differences in pubertal stage, and associations between puberty and body size, were also examined. For each of the anthropometric measures, three stages of analysis were undertaken: a description of trends using observed values; cross-sectional analysis at 11-13yrs (DASH Wave 1) and 14-16yrs (Wave 2); and multilevel modelling to examine trends adjusted for height and pubertal status. Finally, ethnic differences in overweight and obesity are also detailed.

The aims of this chapter were to:

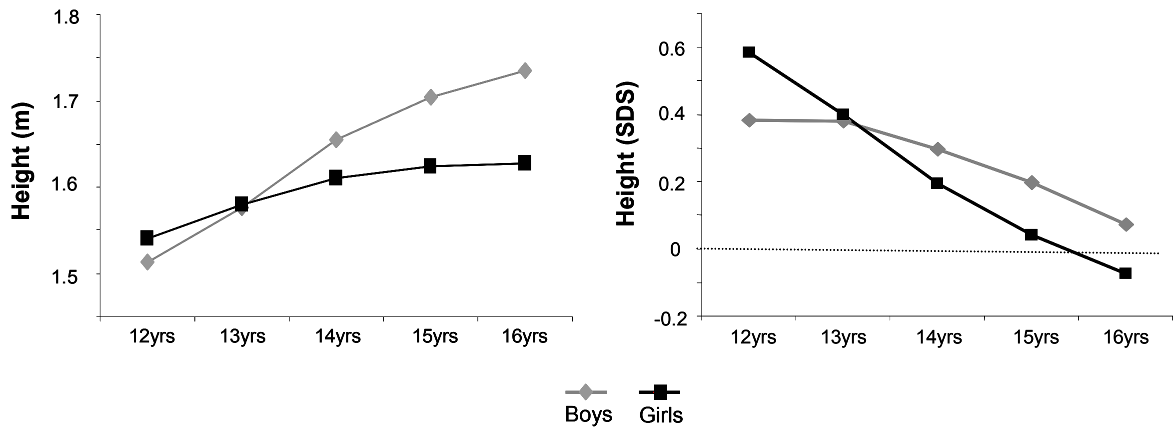
1. Examine overall and ethnic specific trends in body size from 11.5 to 16yrs.
2. Compare how body size trends in this cohort compare to a reference population.
3. Determine whether there were significant ethnic differences in body size, and the age at which they emerged.
4. Investigate the impact of pubertal stage on body size, and on ethnic differences in body size.

3.1 Height

3.1.1 Overall trends in height

The boys gained considerably more height than the girls between 12 and 16yrs and by 14yrs the boys were significantly taller than the girls (Figure 3.1). There was little increase in the girls' mean height after 15yrs, whereas the boys' mean height continued to increase. Relative to the reference population, the DASH pupils were tall for their age in early adolescence but by 16yrs mean heights were close to the reference population values (Figure 3.1).

Figure 3.1 Comparison of boys and girls mean height by age
(a) Mean height (m) **(b) Mean height SDS**

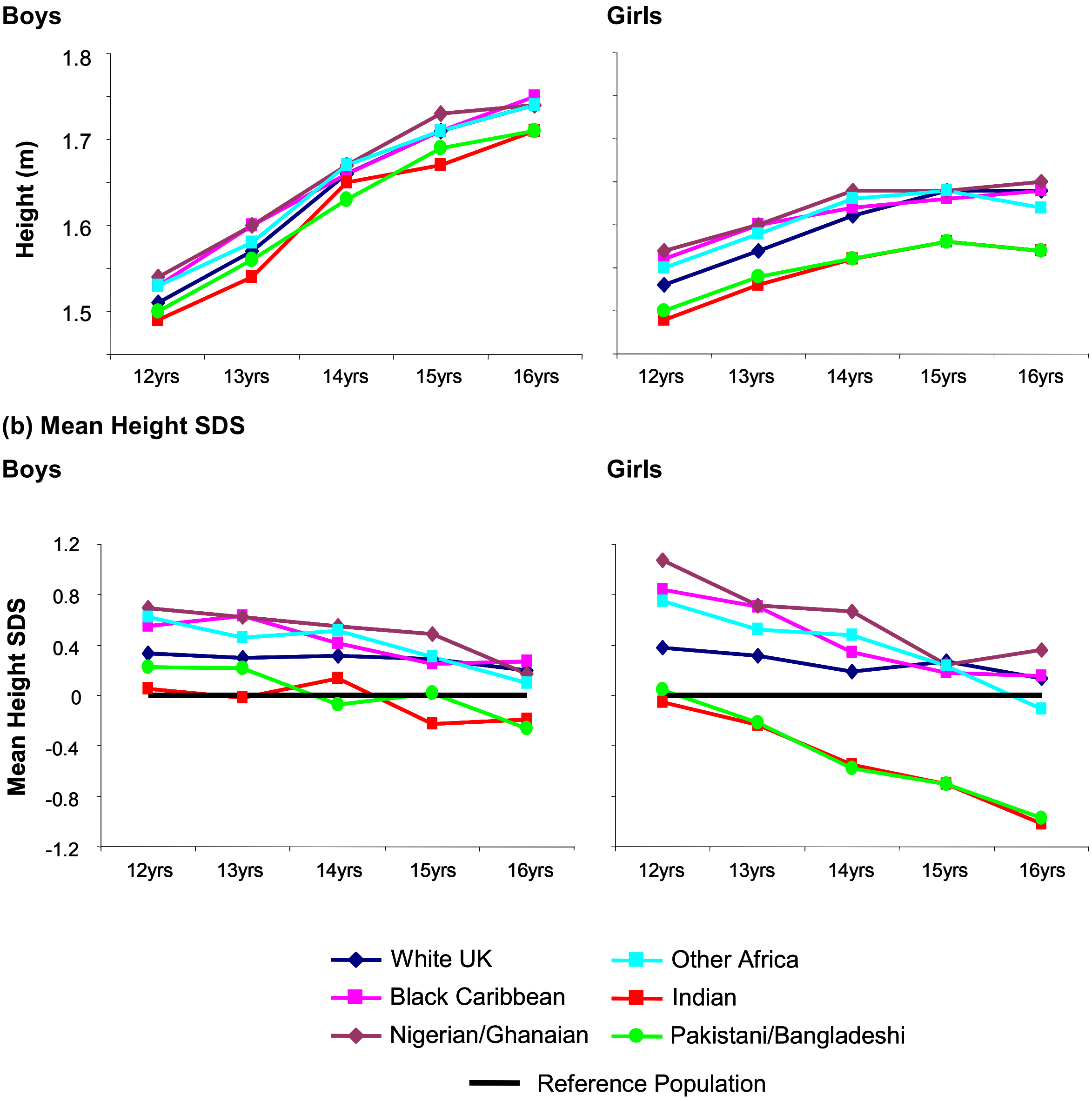


3.1.2 Ethnic differences in height trends

There were ethnic differences in height and these were greater for the girls than the boys (Figure 3.2a). The overall ranking of the ethnic groups by height was similar for both sexes and stayed relatively consistent over the age range (i.e. the shorter groups remained shorter and the taller groups taller). However the White UK boys and girls were the exception to this; they went from being one of the shorter groups at 12yrs to one of the tallest by 16yrs. The tallest ethnic groups tended to be the Black Caribbeans, Other Africans and Nigerian/Ghanaians; from 14yrs onwards the White UK boys and girls were also among the tallest. In contrast, the Indians and Pakistani/Bangladeshis were the shortest at all ages.

At younger ages most, but not all, of the ethnic groups were tall compared to the reference population (Figure 3.2b). The exceptions were the Indian boys and girls, and the Pakistani/Bangladeshi girls. As age increased, there was a gradual decline in SD scores for boys and girls of all ethnic groups except the White UK; their SD score was more stable. By 16yrs, the mean height for most of the groups was still taller than the reference population; only the Pakistani/Bangladeshi and Indian boys and girls, and the Other African girls, had shorter mean heights by this age. Of all the groups, it was the Indian and Pakistani/Bangladeshi girls who had heights most different to the reference population; by 16 years their mean heights were around 1 SD below the reference population mean.

Figure 3.2 Height by age and ethnicity
(a) Mean height in metres



As puberty is a period of rapid growth it was important to examine whether there were ethnic differences in pubertal timing and whether these could explain any of the ethnic differences in height (Table 3.1).

Table 3.1 Pubertal status by ethnicity and sex at 11-13yrs and 14-16yrs

			% in late puberty	OR (95% CI)[1] of being in late puberty
Boys	11-13yrs	White UK	45.5	1.00 (Ref)
		Black Caribbean	57.8	1.65 (1.26 – 2.17)*
		Nigerian/Ghanaian	50.7	1.20 (0.86 – 1.67)
		Other African	48.3	1.06 (0.76 – 1.48)
		Indian	29.1	0.51 (0.36 – 0.71)*
		Pakistani/Bangladeshi	38.0	0.73 (0.54 – 0.98)*
	14-16yrs	White UK	92.9	1.00 (Ref)
		Black Caribbean	95.4	1.50 (0.83 – 2.70)
		Nigerian/Ghanaian	93.7	0.77 (0.57 – 2.15)
		Other African	91.9	0.74 (0.40 – 1.37)
		Indian	88.2	0.57 (0.33 – 0.96)*
		Pakistani/Bangladeshi	89.8	0.64 (0.38 – 1.07)
Girls	11-13yrs	White UK	35.0	1.00 (Ref)
		Black Caribbean	69.7	4.86 (3.54-6.68)*
		Nigerian/Ghanaian	74.1	6.54 (4.59-9.32)*
		Other African	57.6	2.69 (1.83-3.95)*
		Indian	34.8	1.07 (0.72-1.57)
		Pakistani/Bangladeshi	35.7	1.07 (0.70-1.63)
	14-16yrs	White UK	85.3	1.00 (Ref)
		Black Caribbean	95.4	3.57 (2.05-6.21)*
		Nigerian/Ghanaian	97.3	6.25 (2.93-13.35)*
		Other African	89.8	1.49 (0.85-2.63)
		Indian	82.3	0.80 (0.49-1.28)
		Pakistani/Bangladeshi	80.7	0.73 (0.44-1.22)

[1]Adjusted for age. Odds of being in late puberty relative to early/mid puberty.

At 11-13yrs the Black Caribbeans were the most likely to be in late puberty for both boys and girls. Conversely, Indian boys and girls were least likely. Compared to the White UK pupils, the Black Caribbean boys and girls, and the Nigerian/Ghanaian and Other African girls were significantly more likely to be in late puberty at 11-13yrs; the Indian and Pakistani/Bangladeshi boys significantly less likely. By 14-16yrs the majority of pupils in each ethnic group were in late puberty. However there were still significant ethnic differences; the Black Caribbean and Nigerian/Ghanaian girls remained significantly more likely to be in late puberty than their White UK peers, and the Indian boys significantly less likely.

Those in late puberty were taller than those in early puberty (Table 3.2); this was consistent for both boys and girls in all ethnic groups and at both 11-13yrs and 14-16yrs (the only exception being Other African girls at 14-16yrs; this discrepancy is likely due to the small number [n=24] of Other African girls in early puberty at 14-16yrs). However the pattern varied by sex. For boys, the height difference between those in early/mid puberty and those in late puberty was greater at 14-16yrs than it was at 11-13yrs in all ethnic groups. For girls, the opposite was true. The differences in mean height were generally greater for boys. There were few significant ethnic differences in the impact of puberty on height; the difference in heights between the pubertal groups was significantly lower at 14-16yrs for the Pakistani/Bangladeshi boys and for the Other African girls compared to their White UK peers.

Table 3.2 Difference in mean height between those in early/mid vs. late puberty by sex, age and ethnic group

	Age (yrs)	Difference in mean height between those in early/mid and late puberty (cm) [1]					
		White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys	11-13	4.38	4.93	5.95	2.81	4.65	4.28
	14-16	10.22	7.52	6.97	8.64	9.25	6.76*
Girls	11-13	4.71	2.79	6.39	3.27	4.66	4.32
	14-16	2.08	1.73	5.29	-1.94*	3.51	0.29

[1]Calculated as mean height in late puberty minus mean height in early/mid puberty

*Significantly different to White UK value, $p<0.05$ (significance of ethnic differences assessed by fitting interaction between pubertal status and ethnicity in regression model with height as the outcome and adjusted for age).

The next stage of the analysis involved using linear regression models to formally test whether the ethnic differences in height at 11-13yrs and 14-16yrs were statistically significant and whether pubertal status could explain any of the ethnic differences. For the boys, at 11-13yrs the Black Caribbeans, Nigerian/Ghanaians and Other Africans were significantly taller than the White UK boys, and the Indians were significantly shorter (Table 3.3). Adjusting for pubertal status attenuated the ethnic differences in height but they remained significant. The Nigerian/Ghanaian boys were the tallest; their mean height was 2.40cm (0.32SD) taller than the White UK boys. The Indian boys were the shortest; 1.46cm (-0.20SD) shorter than the White UK boys. At 14-16 years, there were no longer any significant height differences between the White UK boys and the Black Caribbean, Nigerian/Ghanaian or Other African boys. Both the Indians and Pakistani/Bangladeshi boys were significantly shorter than the other boys at this age. The Indian boys remained the shortest of all the ethnic groups, with a mean height 3.19cm (-0.40SD) below that of the White UK boys. Both pubertal status and age were strong correlates of height; pubertal status had a larger effect at 14-16yrs than 11-13yrs; the opposite was true for age. The larger pubertal effect at the older ages confirms the finding in Table 3.2 of a larger difference in mean height between the pubertal groups at 14-16yrs compared to 11-13yrs.

For the girls, at 11-13yrs the Black Caribbeans and Nigerian/Ghanaians were significantly taller, and the Indian and Pakistani/Bangladeshis significantly shorter than their White UK peers (Table 3.4). There was no significant difference in height between the Other African and White UK girls after adjusting for pubertal status. At 14-16yrs, there were no significant differences in mean heights between the White UK, Black Caribbean, Nigerian/Ghanaian, and Other African girls. Compared to 11-13yrs, the difference in height between the White UK girls and the Indian and Pakistani/Bangladeshi girls had increased. Pubertal status was a significant correlate at both ages; in contrast to the boys, its effect was larger at 11-13yrs than 14-16yrs. Age was not significantly associated with height at 14-16yrs. This confirms the levelling-off of the girls' heights observed previously (i.e. by late adolescence an increase in age is not associated with a significant increase in height for girls).

In summary, there were significant ethnic differences in height and pubertal status for both boys and girls, and adjustment for pubertal status attenuated some of the ethnic differences in height.

Table 3.3 Boys: Ethnic differences in height (cm and SDS) at 11-13yrs and 14-16yrs

	W1 (11-13yrs)1		W2 (14-16yrs)1	
	Age2	+ Puberty3	Age2	+ Puberty3
Height (cm)				
Ethnicity (Ref: White UK)				
Black Caribbean	2.09*	1.63*	0.14	0.02
Nigerian/Ghanaian	2.57*	2.40*	1.09	1.05
Other African	1.76*	1.70*	-0.18	-0.06
Indian	-2.04*	-1.46*	-3.46*	-3.19*
Pakistani/Bangladeshi	-0.60	-0.32	-3.04*	-2.85*
Age (yrs)	6.29*	5.73*	3.74*	3.53*
Puberty (Late vs. Early/mid)		3.82*		5.89*
Height SDS				
Ethnicity (Ref: White UK)				
Black Caribbean	0.40*	0.24*	-0.01	-0.04
Nigerian/Ghanaian	0.54*	0.36*	0.14	0.11
Other African	0.26*	0.17	-0.05	-0.06
Indian	-0.50*	-0.50*	-1.01*	-1.00*
Pakistani/Bangladeshi	-0.46*	-0.46*	-0.98*	-0.97*
Age (yrs)	-0.19*	-0.29*	-0.15*	-0.16*
Puberty (Late vs. Early/mid)		0.44*		0.23*

[1]Coefficients were estimated using linear regression models for 11-13yrs (Wave 1) and 14-16yrs (Wave 2)

[2]Model adjusted for ethnicity and age

[3]Model Adjusted for ethnicity, age and pubertal status

*p<0.05 compared to reference

Table 3.4 Girls: Ethnic differences in height (cm and SDS) at 11-13yrs and 14-16yrs

	W1 (11-13yrs)[1]		W2 (14-16yrs)[1]	
	Age[2]	+ Puberty[3]	Age[2]	+ Puberty[3]
Height (cm)				
Ethnicity (Ref: White UK)				
Black Caribbean	2.78*	1.70*	-0.06	-0.20
Nigerian/Ghanaian	3.73*	2.49*	0.84	0.67
Other African	1.84*	1.16	-0.31	-0.38
Indian	-3.48*	-3.52*	-6.27*	-6.22*
Pakistani/Bangladeshi	-3.19*	-3.24*	-6.11*	-6.05*
Age (yrs)	3.90*	3.25*	0.50	0.44
Puberty (Late vs. Early/mid)		3.11*		1.40*
Height SDS				
Ethnicity (Ref: White UK)				
Black Caribbean	0.40*	0.24*	-0.01	-0.04
Nigerian/Ghanaian	0.54*	0.36*	0.14	0.11
Other African	0.26*	0.17	-0.05	-0.06
Indian	-0.50*	-0.50*	-1.01*	-1.00*
Pakistani/Bangladeshi	-0.46*	-0.46*	-0.98*	-0.97*
Age (yrs)	-0.19*	-0.29*	-0.15*	-0.16*
Puberty (Late vs. Early/mid)		0.44*		0.23*

[1]Coefficients were estimated using linear regression models for 11-13yrs (Wave 1) and 14-16yrs (Wave 2)

[2]Model adjusted for ethnicity and age

[3]Model Adjusted for ethnicity, age and pubertal status

*p<0.05 compared to reference

3.1.3 Longitudinal height trends

Multilevel models were then used to derive growth trajectories that exploited the longitudinal data and to examine the influence of pubertal status on these trajectories. Modelling of the longitudinal data allowed the entire distribution of height observations from 11.5yrs to 16yrs to be used to examine the height trajectories of each of the ethnic groups. Due to the complexity of these models, it was difficult to interpret the relationship between the covariates (age, pubertal status, ethnicity) and the height outcomes (cm and SDS), and whether there were significant ethnic differences in the outcomes, by simply looking at the regression coefficients. Instead, predicted values were calculated and plotted to produce smooth growth curves. These provide a detailed picture of ethnic differences in height trends in adolescence.

The figures show trends in height (cm and SDS) between 11.5 and 16 years stratified by ethnic group for boys (Figure 3.3) and girls (Figure 3.4) for null models (adjusted for age only) and baseline models (adjusted for age and pubertal status). These figures confirm the ethnic trends observed in the descriptive analysis, and have the advantage of being able to reveal the ethnic differences in the height trajectories more clearly. They highlight that by 16 years, for both boys and girls, there were two distinct height groups; the Black Caribbean, Nigerian/Ghanaian, Other African and White UK pupils were in the taller group and the Indian and Pakistani/Bangladeshi in the shorter one. The greater magnitude of the ethnic differences for girls compared to boys is also evident.

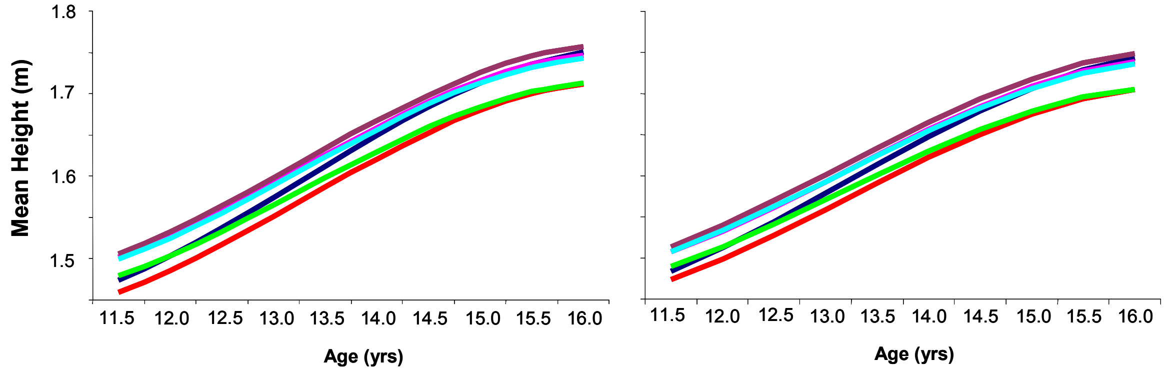
The girls' and boys' growth curves differ; for girls, all groups have their fastest pace of growth (as determined by the slope of the curves) from 11.5yrs to approximately 13.5-14yrs. In contrast the boys' fastest period of growth starts at a slightly older age, around 12.5yrs, and although it begins to tail off slightly at 15 years mean height continues to increase. However there is no indication that the shorter groups (Indians and Pakistani/Bangladeshis) have catch-up growth in later adolescence (their growth curves begin to tail off post 15yrs in a comparable way to the taller groups).

The figures also emphasise the greater height gained by the White UK boys and girls between 11.5 and 16yrs relative to their peers, and that the other groups all had a similar pace of growth to each other between these ages. It is particularly striking how different the White UK and Pakistani/Bangladeshi boys' heights were at 16yrs given they were the same height at the youngest ages. Also of note is that the White UK boys' and girls' height SDS lines are almost horizontal (therefore almost parallel to the reference population). In contrast, all of the other groups had a decrease in SD score with increasing age.

The cross-sectional analysis showed that pubertal status was associated with height and could attenuate some of the ethnic differences in height. However adjusting for pubertal status made little difference to the overall trends. Ethnic differences did decrease slightly but ethnic differences in pubertal stage did not explain the ethnic differences in height trends. Many of the ethnic differences in height appear to be established before the age period covered in the DASH study (therefore probably before puberty). This is a possible explanation of why adjustment for pubertal status only explained a very small amount of the ethnic height trend differences in adolescence.

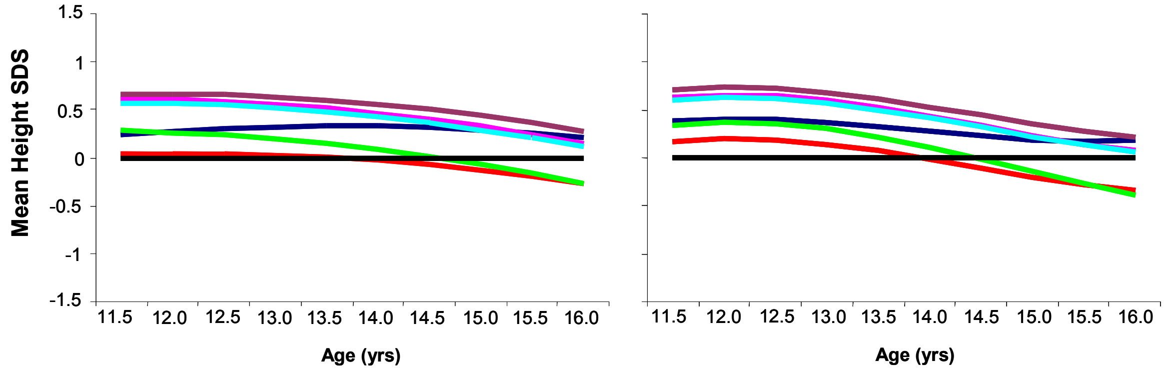
Figure 3.3 Boys: Predicted Height by age
(a) Height in metres[1]

Null **Baseline**



(b) Height SDS[2]

Null **Baseline**



[1]Height (m)

Null Model: ethnicity*age, age^2

Baseline model: ethnicity*age, age^2, age^3, pubertal status

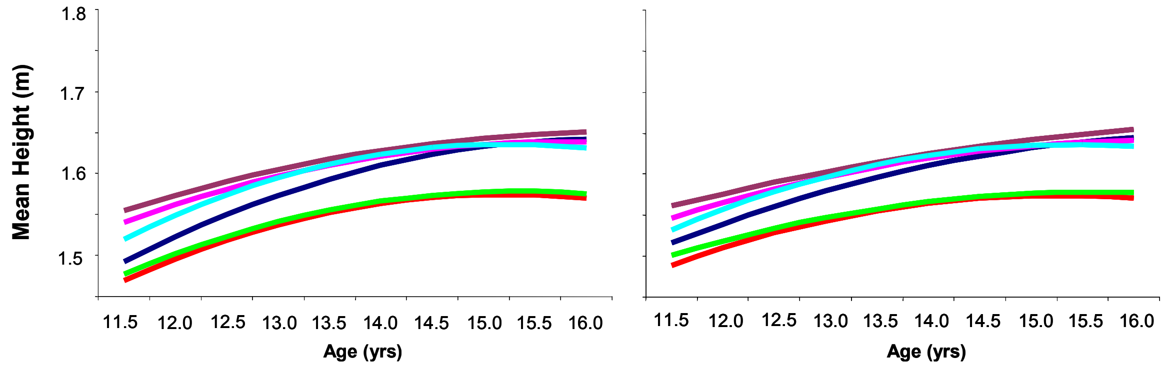
[2]Height SDS

Null Model: ethnicity*age, age^2, ethnicity*age^3

Baseline Model: ethnicity*age, age^2, ethnicity*age^3, pubertal status

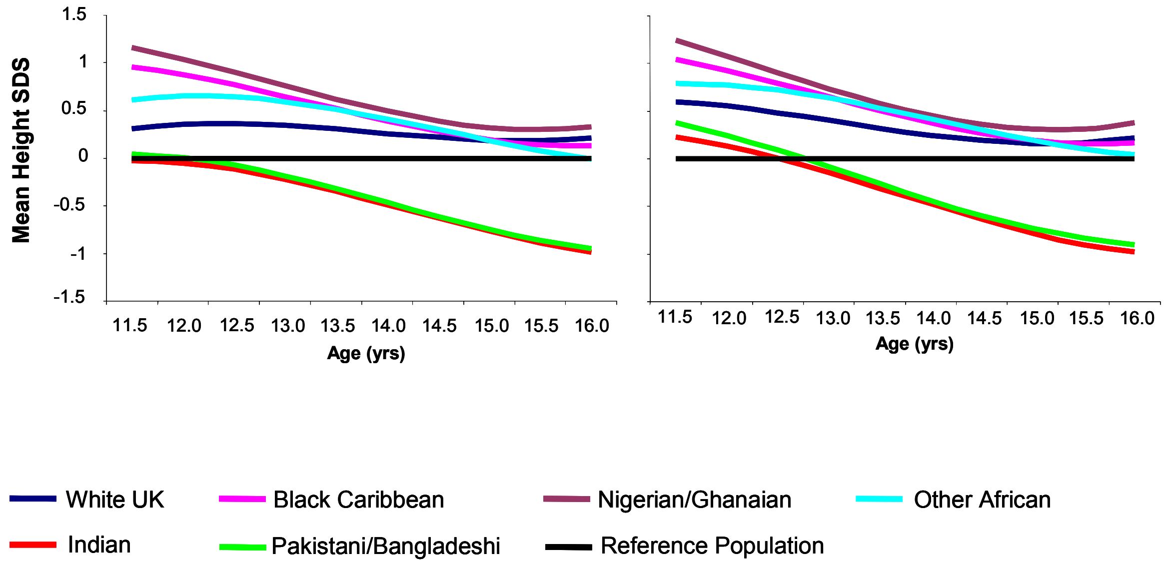
Figure 3.4 Girls: Predicted Height by age
(a) Height in metres[1]

Null **Baseline**



(b) Height SDS[2]

Null **Baseline**



[1]Height (m)

Null Model: ethnicity*age, ethnicity*age^2

Baseline model: ethnicity*age, ethnicity*age^2, pubertal status*age

[2]Height SDS

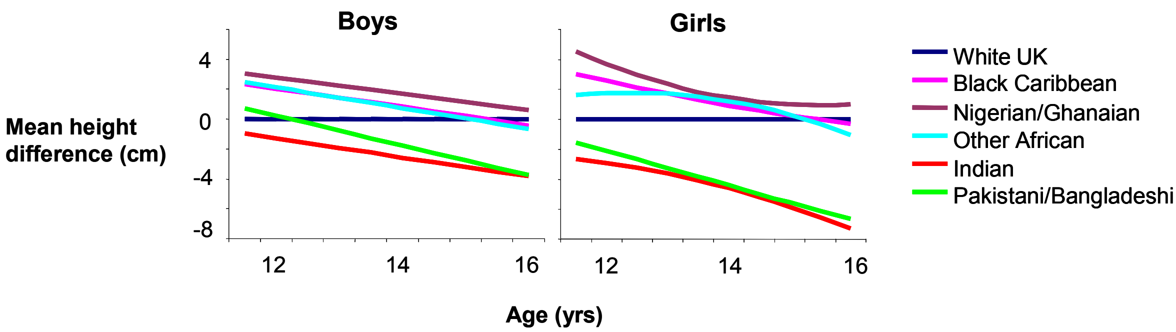
Null Model: ethnicity*age, ethnicity*age^2

Baseline Model: ethnicity*age, ethnicity*age^2, age^3, pubertal status*age

An alternative way to view the results from the longitudinal models is to plot how the differences between the ethnic minority groups and their White UK peers change with increasing age (Figure 3.5). This emphasises how ethnic differences change as the pupils grow older. An advantage of the longitudinal analysis is that it is possible to determine more precisely than in the cross-sectional analysis when ethnic differences gain or lose statistical significance.

Figure 3.5 Ethnic differences in mean height (cm) compared to White UK by age

(from baseline model - adjusted for pubertal status)



For boys, at 11.5yrs the Indians were significantly shorter (-0.98 cm) and the Black Caribbeans (2.36cm), Nigerian/Ghanaians (3.08cm) and Other Africans (2.47cm) significantly taller than the White UK boys. With increasing age, these ethnic differences in height decreased for many of the groups; by 13.5yrs the other Africans were no longer significantly taller than the White UK boys, this happened for the Black Caribbeans at 14yrs and the Nigerian/Ghanaians at 15yrs. By 16yrs the differences between these 4 groups were small. In contrast, ethnic differences in height increased for the Indian and Pakistani/Bangladeshi boys, with the Pakistani/Bangladeshis becoming significantly shorter than their White UK peers at 13.5yrs. By 16yrs they were 3.76cm shorter, and the Indians 3.83cm shorter.

Similar to the boys, the height differences between the White UK and the Black Caribbean, Nigerian/Ghanaian, and Other African girls decreased with increasing age (becoming non-significant at 14yrs, 15yrs and 14.5yrs respectively). For example, the Black Caribbean girls were an average of 3.04cm taller than their White UK peers at 11.5yrs but 0.28cm shorter by 16yrs. As with the boys, the height difference between the White UK girls and the Indian and Pakistani/Bangladeshi girls increased with increasing age. At 11.5yrs, the

Indian girls were 2.67cm shorter, this increased to 7.31cm at 16yrs. The equivalent figures for the Pakistani/Bangladeshis were 1.54cm and 6.65cm.

3.1.4 Height - Key points

- Overall the boys and girls were tall for their age in early adolescence, but had heights close to the reference population by 16yrs.

- Ethnic differences in height were greater for girls than boys but general ethnic patterns were similar for both sexes.

- Black Caribbean, Nigerian/Ghanaian, Other African (and White UK from approximately 14yrs) were the tallest groups.

- Indians and Pakistani/Bangladeshis had the shortest heights at all ages, and were short relative to reference population by 16yrs (particularly the girls).

- White UK boys and girls gained more height than their peers between 11.5 and 16yrs.

- Pubertal status was a strong correlate of height, particularly for boys at 14-16yrs and girls at 11-13yrs.

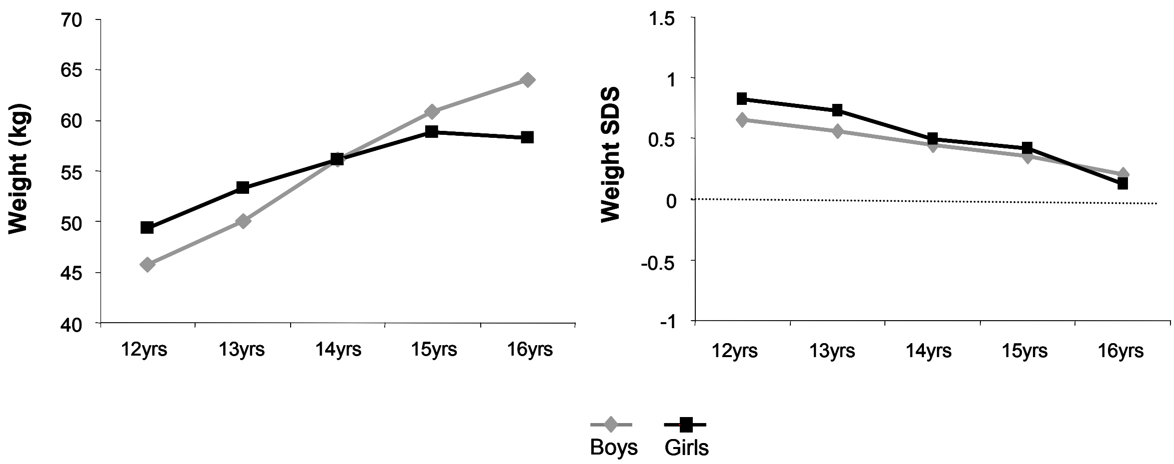
- Adjusting for pubertal status attenuated some of the ethnic differences in height.

3.2 Weight

3.2.1 Overall trends in weight

The boys gained more weight than the girls between 12yrs and 16yrs and were heavier than the girls after 14yrs (Figure 3.6). The overall weight trends mirror those observed for height; the boys continued to gain weight up to 16 years whereas the girls did not on average gain additional weight between 15yrs and 16yrs. Mean weight SD scores were similar for boys and girls; at all ages they weighed more than their reference population counterparts but by later adolescence their weight was closer to the reference population mean.

Figure 3.6 Comparison of boys and girls mean weights by age
(a) Mean weight (kg) **(b) Mean weight (SDS)**



3.2.2 Ethnic differences in weight trends

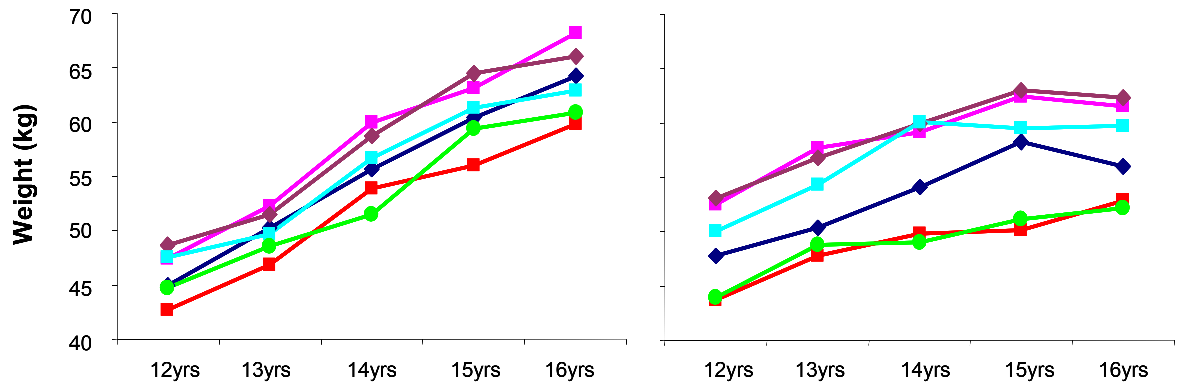
As with height, the ethnic differences in weight were smaller for the boys than the girls (Figure 3.7). Ethnic differences were relatively constant over the age range due to a similar pace of weight gain in each ethnic group. In general, the Indians and Pakistani/Bangladeshis were the lightest groups, the Black Caribbean, Nigerian/Ghanaian and Other Africans were the heaviest groups, and the White UK pupils lay in between (the exception being that the White UK boys were heavier than the Other African boys by 16 years).

A decline in SD score with increasing age was apparent in all sex and ethnic groups; this decline was less in some groups (e.g. Black Caribbean boys) than others (e.g.

Pakistani/Bangladeshi girls) (Figure 3.7b). By 16 years, the White UK girls had a mean weight just below the reference population but the White UK boys still weighed more than their reference counterparts. The Black Caribbean, Nigerian/Ghanaian, and Other African boys and girls had SD scores greater than 0 at all ages.

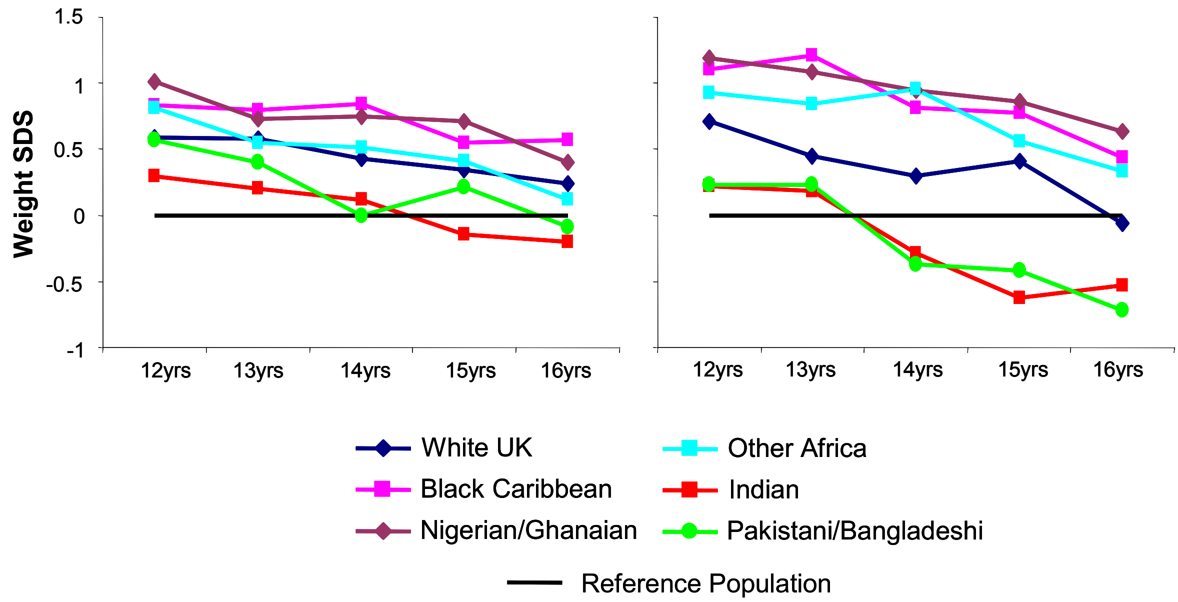
Figure 3.7 Weight by age and ethnicity
(a) Mean weight (kg)

Boys **Girls**



(b) Mean weight SDS

Boys **Girls**



Those in late puberty were consistently heavier than those in early puberty (Table 3.5). For boys the weight difference was generally greater at 14-16yrs than 11-13yrs (an exception being the Nigerian/Ghanaians). For girls there was no clear picture; for some groups weight difference was greater at the younger ages, for others at the older ages.

Table 3.5 Difference in mean weight between those in early/mid and late puberty by sex, age and ethnic group

	Age (yrs)	Difference in mean weight between those in early/mid vs. late puberty (kg) [1]					
		White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys	11-13	4.78	4.01	7.70	2.66	6.15	1.90
	14-16	11.05	8.38	7.51	8.87	10.72	6.12
Girls	11-13	7.27	6.27	7.95	6.33	3.21	5.52
	14-16	3.48	7.95	5.85	4.32	6.58	3.37

[1]Calculated as mean weight in late puberty minus mean weight in early/mid puberty

As would be expected, the heavier ethnic groups were the taller ones. Ethnic differences in weight were therefore examined at 11-13yrs and 14-16yrs adjusting for age, pubertal status, and height. For boys, after adjustment for pubertal status and age, the Black Caribbean and Nigerian/Ghanaian boys were significantly heavier than the White boys at both 11-13yrs and 14-16yrs (Table 3.6). Once height was also adjusted for, these differences became insignificant at 11-13yrs but remained significant at 14-16yrs (as was reported in the height section, the Black Caribbean and Nigerian/Ghanaian boys were not significantly taller than the White UK boys at 14-16yrs; therefore adjustment for height did not explain their greater weight at this age). In contrast, the shorter height of the Indian and Pakistani/Bangladeshi boys at 14-16yrs did explain their lighter weights. The association between height and weight was of similar magnitude at both ages. Pubertal status was independently associated with weight at 14-16yrs but not at 11-13yrs, but once height was controlled for it became a non-significant correlate.

In contrast to the boys, the Black Caribbean and Nigerian/Ghanaian girls were already significantly heavier than the White UK girls at 11-13yrs after adjustment for pubertal status and height (Table 3.7). By 14-16yrs the weight difference between the White UK girls and these groups had increased to over 4kg for both the Black Caribbeans and Nigerian/Ghanaians. The Other Africans were also significantly heavier than the White UK girls at 14-16yrs. Similar to the boys, the Indian and Pakistani/Bangladeshi girls were lighter but this was explained by their shorter heights. Height and pubertal status were both independently associated with weight at 11-13yrs and 14-16yrs.

Table 3.6 Boys: Ethnic differences in weight (kg and SDS) at 11-13yrs and 14-16yrs

	W1 (11-13yrs)[1]			W2 (14-16yrs)[1]		
	Age[2]	+ Puberty[3]	+ Height[4]	Age[2]	+ Puberty[3]	+ Height[4]
Weight (kg)						
Ethnicity (Ref: White UK)						
Black Caribbean	2.67*	2.22*	0.61	3.39*	3.22*	3.22*
Nigerian/Ghanaian	2.50*	2.33*	-0.06	3.19*	3.13*	2.20*
Other African	1.39	1.33	-0.36	-0.28	-0.12	-0.07
Indian	-2.13*	-1.56	-0.11	-4.39*	-4.03*	-1.05
Pakistani/Bangladeshi	0.63	-0.35	-0.03	-2.69*	-2.43*	0.25
Age (yrs)	4.57*	4.03*	5.05*	3.76*	3.25*	4.76*
Puberty (Late vs. Early/mid)		3.77*	0.13		7.79*	2.52*
Height (SDS)			7.39*			7.40*
Weight SDS						
Ethnicity (Ref: White UK)						
Black Caribbean	0.25*	0.21*	0.04	0.28*	0.26*	0.26*
Nigerian/Ghanaian	0.27*	0.26*	0.01	0.31*	0.30*	0.21*
Other African	0.11	0.11	-0.07	-0.03	-0.02	-0.01
Indian	-0.31*	-0.25*	-0.10	-0.47*	-0.43*	-0.15
Pakistani/Bangladeshi	-0.09	-0.07	-0.03	-0.28*	-0.25*	0.00
Age (yrs)	-0.10*	-0.16*	-0.05	-0.16*	-0.22*	-0.08
Puberty (Late vs. Early/mid)		0.38*	-0.00		0.83*	0.33*
Height (SDS)			0.77*			0.70*

[1]Coefficients were estimated using linear regression models for 11-13yrs (Wave 1) and 14-16yrs (Wave 2)

[2]Model adjusted for age only

[3]Model Adjusted for age and pubertal status

[4]Model Adjusted for age, pubertal status, and height SDS, *p<0.05 compared to reference

Table 3.7 Girls: Ethnic differences in weight (kg and SDS) at 11-13yrs and 14-16yrs

	W1 (11-13yrs)[1]			W2 (14-16yrs)[1]		
	Age[2]	+ Puberty[3]	+ Height[4]	Age[2]	+ Puberty[3]	+ Height[4]
Weight (kg)						
Ethnicity (Ref: White UK)						
Black Caribbean	6.30*	4.51*	2.88*	4.69*	4.18*	4.38*
Nigerian/Ghanaian	6.25*	4.19*	1.78*	5.22*	4.62*	4.03*
Other African	3.95*	2.82*	1.70	2.36*	2.14	2.48*
Indian	-2.91*	-2.98*	0.40	-6.11*	-5.96*	-0.50
Pakistani/Bangladeshi	-3.06*	-3.13*	-0.03	-5.58*	-5.36*	-0.09
Age (yrs)	4.21*	3.13	5.04*	0.84	0.64	1.51*
Puberty (Late vs. Early/mid)		5.16*	2.20*		5.00*	3.77*
Height (SDS)			6.69*			5.43*
Weight (SDS)						
Ethnicity (Ref: White UK)						
Black Caribbean	0.57*	0.38*	0.21*	0.42*	0.36*	0.38*
Nigerian/Ghanaian	0.61*	0.39*	0.14	0.53*	0.46*	0.39*
Other African	0.40*	0.28*	0.16*	0.25*	0.23	0.26*
Indian	-0.35*	-0.35	-0.01	-0.80*	-0.78*	-0.18
Pakistani/Bangladeshi	-0.36*	-0.36*	-0.05	-0.75*	-0.72	-0.14
Age (yrs)	-0.09	-0.20*	-0.01	-0.21*	-0.24*	-0.14*
Puberty (Late vs. Early/mid)		0.55*	0.25*		0.61*	0.47*
Height (SDS)			0.68*			0.60*

[1]Coefficients were estimated using linear regression models for 11-13yrs (Wave 1) and 14-16yrs (Wave 2)

[2]Model adjusted for age only

[3]Model Adjusted for age and pubertal status

[4]Model Adjusted for age, pubertal status, and height SDS, *p<0.05 compared to reference

3.2.3 Longitudinal weight trends

For boys, the relationship between weight and age was almost linear in every group; unlike height there was no evidence of weight gain tailing off with increasing age (Figure 3.8). Ethnic differences in weight gradually increased with increasing age; the different gradients of the slopes show that some groups (e.g. the Black Caribbeans and Nigerian/Ghanaians) gained more weight per year than the others. The Other African boys gained less weight per year than the other groups; they had a mean weight almost identical to the Black Caribbeans and Nigerian/Ghanaians at 11.5yrs however by 16yrs they weighed less than the White UK boys.

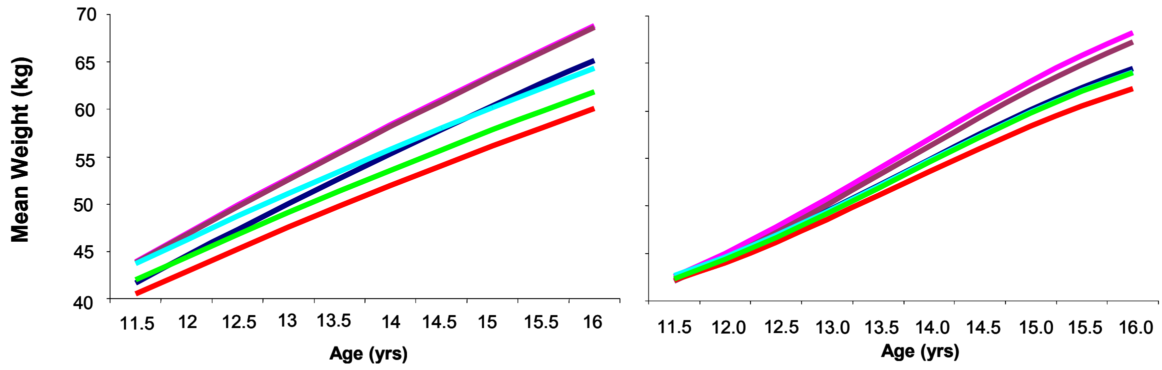
Unlike the boys, the girls' weights did not increase in a linear fashion; the rate of weight increase began to tail off around 14yrs for the Indian and Pakistani/Bangladeshi girls, around 14.5yrs for the Black Caribbean, Nigerian/Ghanaian and Other African girls, and approximately 15yrs for the White UK girls (Figure 3.9). The magnitude of the weight difference between the lightest groups (Indians and Pakistani/Bangladeshis) and the heaviest (Black Caribbean, Nigerian/Ghanaian, Other African) was fairly constant over time. At the youngest ages, the White UK girls had a mean weight which was slightly higher than the Pakistani/Bangladeshi and Indian girls and well below that of the other groups; however by 16 years they had weights much closer to the heavier groups.

Adjustment for pubertal stage and height considerably reduced ethnic differences in weight for both boys and girls across the age range, and there were no ethnic differences for the younger boys after adjustment for these covariates. Therefore many of the ethnic differences in weight were due to some groups being taller and more likely to be in late puberty. For boys, after adjustment for height and pubertal stage there was no difference in weight at any age between the Pakistani/Bangladeshi, White UK, and Other African boys (Figure 3.8 and Figure 3.10). However these factors did not explain the greater weight of the Black Caribbean and Nigerian/Ghanaian boys relative to the White UK boys at the older ages. They become significantly heavier than the White UK boys at 13.5 and 15yrs respectively, and by 16 years they weighed 3.84kg (Black Caribbean) and 2.84kg (Nigerian/Ghanaian) more than the White boys. This is a different pattern from that observed for height (where the difference between the White UK boys and the Black Caribbeans and Nigerian/Ghanaians decreased with increasing age). Height and pubertal status did not explain the Indian boys lighter weight at older ages; they became significantly lighter than the White UK boys at 15.5yrs. By 16yrs they were 2.09kg lighter.

For girls, the White UK girls had mean weights very close to the Indian and Pakistani/Bangladeshi girls at all ages after adjustment for height and pubertal status (Figure 3.9 and Figure 3.10). However these factors did not fully account for why the other groups had consistently higher weights at all ages. For example, at 11.5yrs, the Black Caribbeans (3.76kg heavier), Nigerian/Ghanaians (2.65kg) and Other Africans (2.50kg) were already significantly heavier than the White UK girls. The difference between the White UK and Other African girls stayed almost constant over time and this is reflected in their near parallel lines. In contrast, the other two groups put on weight at a faster rate than the White UK girls resulting in ethnic differences increasing; at 16 years the Black Caribbeans were 4.72kg heavier than the White UK girls, and the Nigerian/Ghanaians 4.52kg heavier.

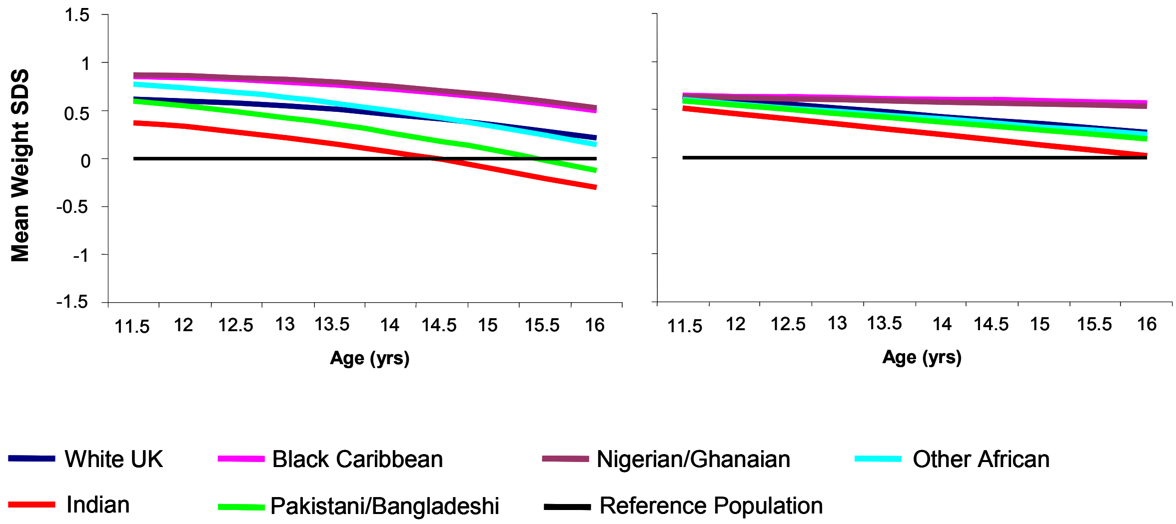
Figure 3.8 Boys: Predicted Weight by age
(a) Weight in kg[1]

Null **Baseline**



(b) Weight SDS[2]

Null **Baseline**



[1]Weight (kg)

Null Model: ethnicity*age, age^2

Baseline model: ethnicity*age, age^2, age^3, pubertal status*age, pubertal status*height SDS

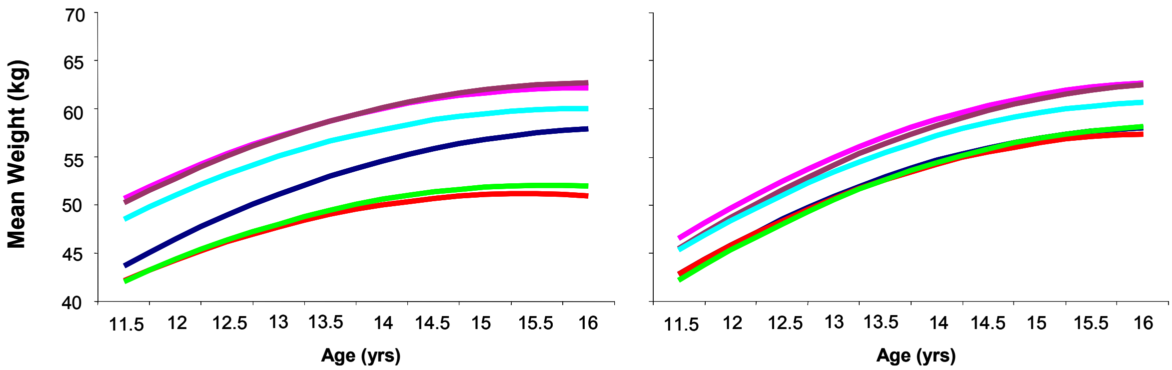
[2]Weight SDS

Null Model: ethnicity*age, age^2

Baseline Model: ethnicity*age, age^2, pubertal status, height SDS

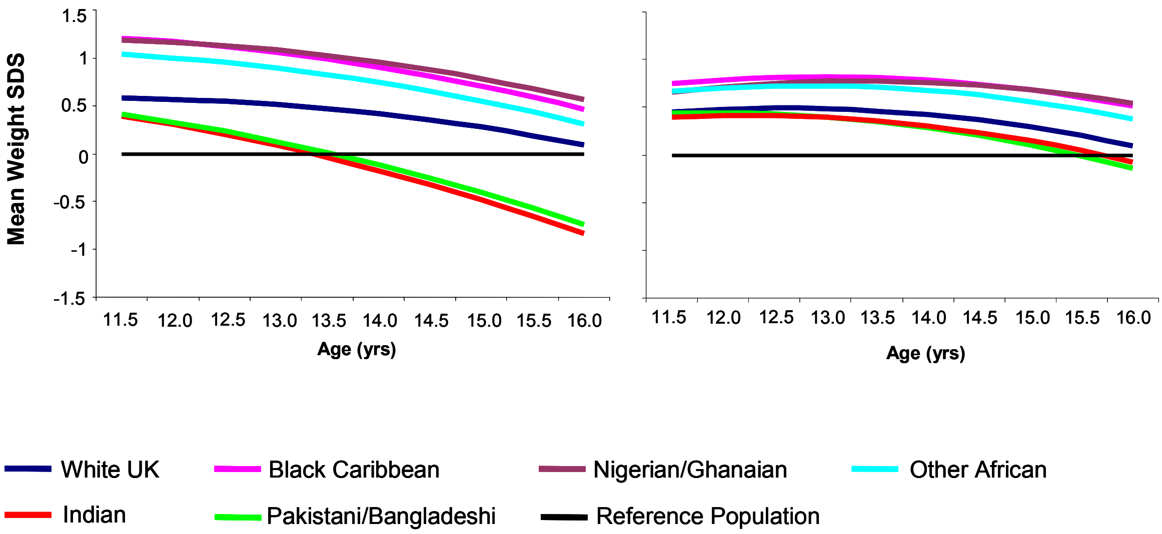
Figure 3.9 Girls: Predicted Weight by age
(a) Weight in kg[1]

Null **Baseline**



(b) Weight SDS[2]

Null **Baseline**



[1]Weight (kg)

Null Model: ethnicity*age, age^2

Baseline model: ethnicity*age, age^2, pubertal status*age, height SDS

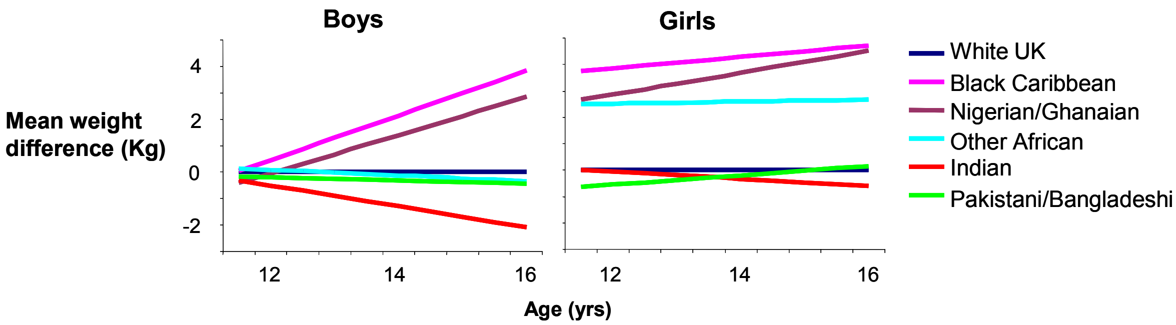
[2]Weight SDS

Null Model: ethnicity*age, age^2

Baseline Model: ethnicity*age, age^2, pubertal status*age, height SDS

Figure 3.10 Ethnic differences in mean weight (kg) compared to White UK by age

(adjusted for pubertal status and height)



3.2.4 Weight - Key Points

- Overall, the pupils were heavy in early adolescence relative to the reference population.

- The ethnic patterns in weight reflect those for height; therefore adjustment for height and pubertal status attenuated the ethnic differences in weight.

- Among boys, in early adolescence there were no ethnic differences in weight after adjustment for puberty and height; however by 16yrs Black Caribbean and Nigerian/Ghanaian boys were significantly heavier and the Indian boys significantly lighter than their White UK peers after these adjustments.

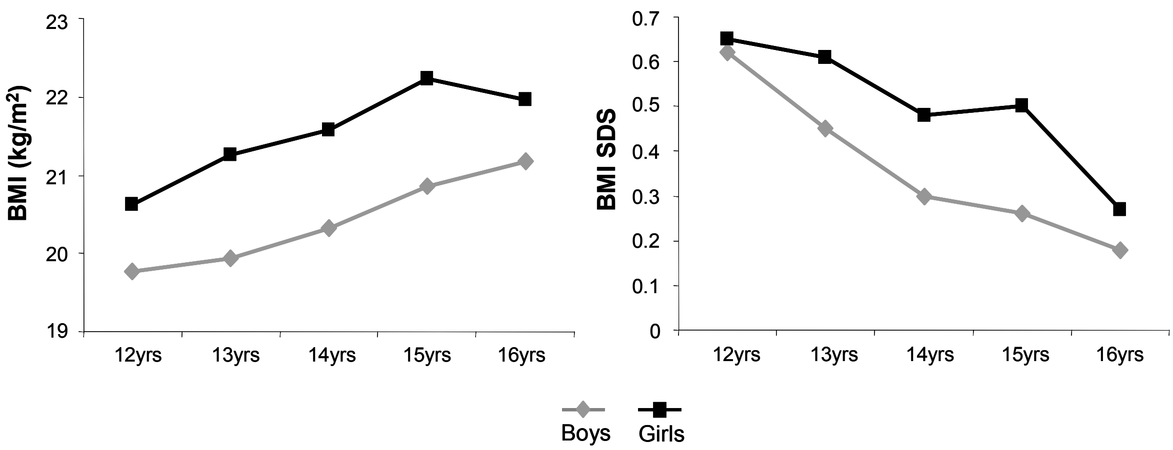
- Among girls, ethnic differences already existed at 11.5yrs and these persisted with increasing age; at all ages the Black Caribbean, Nigerian/Ghanaian and Other African girls were significantly heavier than the other girls.

3.3 Body Mass Index (BMI)

3.3.1 Overall trends in BMI

Girls had higher mean BMI measurements than boys at all ages (Figure 3.11). For both sexes, mean BMI gradually increased with increasing age (the exception being for girls between 15yrs and 16yrs). At 12yrs both boys and girls had a mean BMI which was more than 0.6 standard deviations greater than the reference population. Although mean BMI SD scores decreased with increasing age (except for girls between 14 and 15yrs), by 16yrs values remained higher than the reference population.

Figure 3.11 Comparison of boys and girls mean BMI by age
(a) BMI (kg/m^2) **(b) BMI SDS**



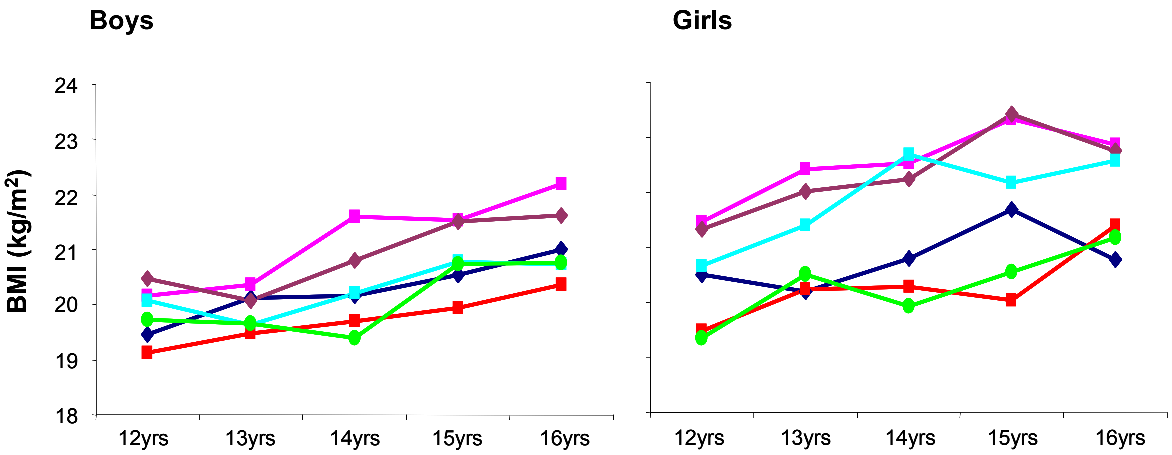
3.3.2 Ethnic differences in BMI trends

As was seen for height and weight, ethnic differences in BMI were greater for girls than boys (Figure 3.12). The magnitude of ethnic differences increased with age for the boys; however at all ages, the Black Caribbean and Nigerian/Ghanaian boys tended to have the highest mean BMIs, and the Indian boys the lowest. In contrast to the boys, clear ethnic differences in BMI were already apparent at 12yrs for the girls. There were 3 clusters; the Black Caribbean and Nigerian/Ghanaian girls with the highest mean BMIs, the Indians and Pakistani/Bangladeshis with the lowest mean BMIs, and the Other African and White UK girls in the middle. However by age 16 years, these three clusters had divided into two; the Black Caribbean, Nigerian/Ghanaian, and Other African groups in the higher BMI group and the Indians, Pakistani/Bangladeshis and White UK girls in the lower BMI group.

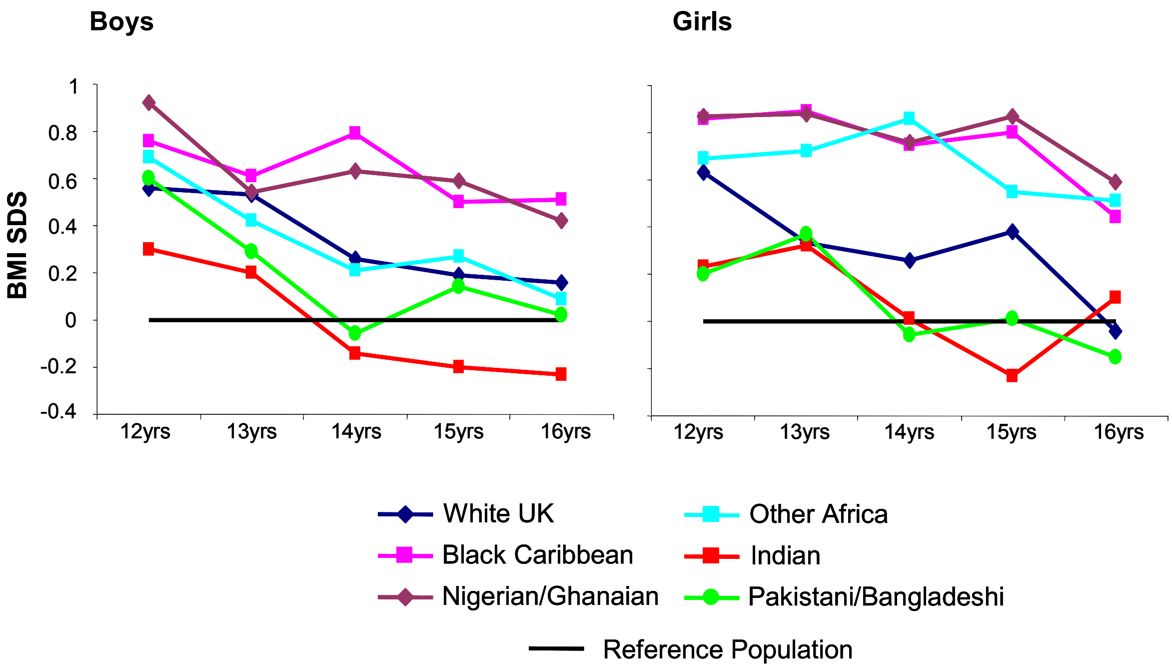
For both sexes, all of the ethnic groups had mean BMIs greater than the reference population at 12yrs (Figure 3.12b). Mean SD scores were lower at 16yrs compared to

12yrs in all groups; however the magnitude of the decline varied. By 16yrs, several of the groups had mean BMI SD scores close to or below 0. However mean scores remained relatively high for the Black Caribbean and Nigerian/Ghanaian boys and girls, and the Other African girls.

Figure 3.12 BMI by age and ethnicity
(a) BMI (kg/m^2)



(B) BMI SDS



In every ethnic group (with the exception of Pakistani/Bangladeshi boys at 11-13yrs) those in late puberty had higher mean BMIs than those in early/mid puberty (Table 3.8). The differences were generally greater for the girls than the boys. Although the mean differences varied by ethnicity, there were no significant ethnic differences relative to the White UK boys and girls.

Table 3.8 Difference in mean BMI (kg/m^2) between those in early/mid and late puberty by sex, age and ethnic group

	Age (yrs)	Difference in mean BMI between those in early/mid vs. late puberty (kg/m^2) [1]					
		White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys	11-13	0.85	0.31	1.53	0.37	1.34	-0.27
	14-16	1.54	0.92	1.03	1.06	1.86	0.70
Girls	11-13	1.73	1.86	1.55	1.74	0.22	1.33
	14-16	0.78	2.35	0.73	2.15	1.79	1.32

[1]Calculated as mean BMI in late puberty minus mean BMI in early/mid puberty

The significance of the ethnic differences in BMI, and the impact of pubertal status and height on them, was examined at 11-13yrs and 14-16yrs. For boys, the higher mean BMI of the Black Caribbeans relative to the White UK at 11-13yrs was not significant after adjustment for pubertal status and height (Table 3.9). There were no other significant ethnic differences in BMI for boys at this age. By 14-16yrs ethnic differences had increased; however after adjustment for pubertal status and height, only the Black Caribbean boys had mean BMIs significantly different to the White UK boys. Height was a significant correlate of BMI; taller boys had higher BMIs. The effect of height on BMI was greater at 11-13yrs than at 14-16yrs. Pubertal status remained significantly associated with BMI at 14-16yrs after the addition of height into the model (those in later puberty had a higher mean BMI than those in early/mid puberty). However at the younger ages, height explained the association between puberty and BMI (i.e. those in late puberty were taller than those in early/mid puberty, and the taller individuals had higher BMIs).

Significant ethnic differences in BMI were already apparent for girls at 11-13yrs; the Black Caribbean, Nigerian/Ghanaian, and Other African girls had mean BMIs significantly higher than the White UK girls after adjustment for age and pubertal status (Table 3.10). However after the addition of height into the model, only the Black Caribbean girls' mean BMI remained significantly higher than the White UK girls'. By 14-16yrs, the difference in mean BMI between the White UK girls and each of the other groups had increased. Compared to the White UK girls, the Black Caribbean, Nigerian/Ghanaian, and Other African girls had significantly higher BMIs independent of pubertal status and height. In contrast the Indian and Pakistani/Bangladeshi girls had lower mean BMIs than the White UK girls; these differences were not statistically significant but were greater than those observed at 11-13yrs. Age was a significant correlate only at 11-13yrs. In contrast to the boys, pubertal status was an independent correlate of BMI after adjustment for height at both 11-13yrs and 14-16yrs. Similar to the boys, the effect of height on BMI was greater at 11-13yrs than 14-16yrs; conversely the effect of pubertal status was greater at 14-16yrs than 11-13yrs.

Table 3.9 Boys: Ethnic differences in BMI at W1 and W2

	11-13yrs[1]			14-16yrs[1]		
	Age[2]	+ Puberty[3]	+ Height[4]	Age[2]	+ Puberty[3]	+ Height[4]
BMI						
Ethnicity (Ref: White UK)						
Black Caribbean	0.54*	0.47	0.19	1.07*	1.04*	1.02*
Nigerian/Ghanaian	0.38	0.35	-0.05	0.77*	0.76*	0.65
Other African	0.07	0.06	-0.23	-0.13	-0.10	-0.13
Indian	-0.40	-0.33	-0.14	-0.66	-0.59	-0.36
Pakistani/Bangladeshi	-0.08	-0.05	-0.01	-0.21	-0.17	0.04
Age (yrs)	0.29	0.21	0.35*	0.40*	0.30	0.43*
Puberty (Late vs. Early/mid)		0.55*	0.00		1.45*	1.01*
Height (SDS)			1.10*			0.62*
BMI SDS						
Ethnicity (Ref: White UK)						
Black Caribbean	0.16	0.14	0.04	0.36*	0.34*	0.33*
Nigerian/Ghanaian	0.17	0.16	0.02	0.37*	0.36*	0.32*
Other African	0.01	0.01	-0.09	-0.02	-0.01	-0.23
Indian	-0.28*	-0.25*	-0.19	-0.41*	-0.38*	-0.28*
Pakistani/Bangladeshi	-0.10	-0.09	-0.07	-0.14	-0.12	-0.04
Age (yrs)	-0.14*	-0.17*	-0.12	-0.07	-0.11*	-0.06
Puberty (Late vs. Early/mid)		0.20*	0.01		0.68*	0.51*
Height (SDS)			0.39*			0.25*

[1]Coefficients were estimated using linear regression models for 11-13yrs (Wave 1) and 14-16yrs (Wave 2)

[2]Model adjusted for ethnicity and age

[3]Model Adjusted for ethnicity, age and pubertal status

[4]Model Adjusted for ethnicity, age, pubertal status and height SDS

*p<0.05 compared to reference

Table 3.10 Girls: Ethnic differences in BMI at W1 and W2

	11-13yrs			14-16yrs		
	Age[2]	+ Puberty[3]	+ Height[4]	Age[2]	+ Puberty[3]	+ Height[4]
BMI						
Ethnicity (Ref: White UK)						
Black Caribbean	1.72*	1.26*	1.06*	1.70*	1.54*	1.55*
Nigerian/Ghanaian	1.38*	0.87*	0.58	1.58*	1.40*	1.36*
Other African	1.07*	0.79*	0.63	0.91*	0.84*	0.86*
Indian	-0.37	-0.38	0.04	-0.78	-0.73	-0.39
Pakistani/Bangladeshi	-0.44	-0.46	-0.10	-0.60	-0.53	-0.21
Age (yrs)	0.67*	0.39*	0.64*	0.17	0.10	0.16
Puberty (Late vs. Early/mid)		1.33*	0.96*		1.53*	1.46*
Height (SDS)			0.84*			0.34*
BMI SDS						
Ethnicity (Ref: White UK)						
Black Caribbean	0.43*	0.27*	0.20*	0.43*	0.37*	0.37*
Nigerian/Ghanaian	0.41*	0.23*	0.13	0.48*	0.41*	0.40*
Other African	0.33*	0.23*	0.17	0.30*	0.28*	0.28*
Indian	-0.17	-0.18	-0.04	-0.32*	-0.30*	-0.20
Pakistani/Bangladeshi	-0.17	-0.18	-0.07	-0.26*	-0.24	-0.15
Age (yrs)	-0.03	-0.12	-0.04	-0.13*	-0.16*	-0.14*
Puberty (Late vs. Early/mid)		0.47*	0.35*		0.56*	0.54*
Height (SDS)			0.28*			0.10*

[1]Coefficients were estimated using linear regression models for 11-13yrs (Wave 1) and 14-16yrs (Wave 2)

[2]Model adjusted for ethnicity and age

[3]Model Adjusted for ethnicity, age and pubertal status

[4]Model Adjusted for ethnicity, age, pubertal status and height SDS

*p<0.05 compared to reference

3.3.3 Longitudinal BMI trends

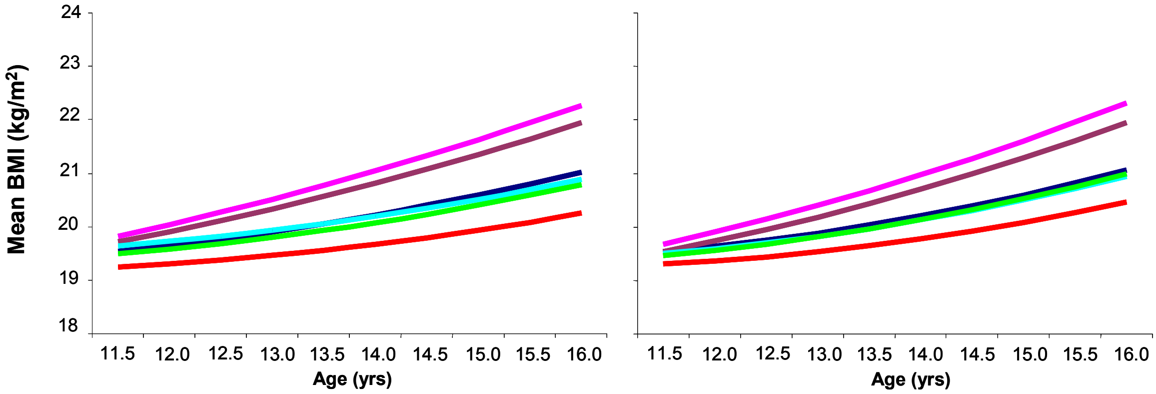
The longitudinal trend figures highlight the emergence of ethnic differences in BMI for boys (Figure 3.13 and Figure 3.15) and the maintenance of ethnic differences for girls (Figure 3.14 and Figure 3.15) as age increases. For boys, adjustment for pubertal status and height made very little difference to the BMI and BMI SDS trends. For girls, adjustment for pubertal status and height reduced the ethnic differences and more clearly separated the girls into two groups; a high BMI group (Black Caribbean, Nigerian/Ghanaian and Other African) and a lower BMI group (White UK, Indian, and Pakistani/Bangladeshi). Therefore, pubertal status and height did not explain the BMI differences between these two groups. The figures quoted in the remainder of this section refer to the models which adjust for pubertal status and height (baseline models).

For boys, there were no significant ethnic differences in BMI at 11.5 years; by 13.5 years the Black Caribbean boys had BMIs significantly greater than the White UK boys (0.64 kg/m^2 greater at 13.5yrs, rising to 1.26 kg/m^2 by 16yrs) (Figure 3.15). By 15yrs the Nigerian/Ghanaians also had significantly higher BMIs than the White UK boys (0.69 kg/m^2 greater at 15 years rising to 0.88 kg/m^2 by 16 yrs). With increasing age the difference between the Indian and White UK boys' BMIs increased (to -0.60 kg/m^2 by 16yrs) although it did not reach statistical significance at any age.

The picture for girls was quite different; at 11.5 years, three of the groups already had mean BMIs significantly higher than the White UK girls; the Black Caribbeans (1.4 kg/m^2), Nigerian/Ghanaians (0.91 kg/m^2) and Other Africans (0.89 kg/m^2) (Figure 3.15). With increasing age, the difference between the Other African and White UK girls increased very slightly to 0.97 kg/m^2. However the ethnic differences between the White UK and the Black Caribbeans and Nigerian/Ghanaians increased considerably to reach 1.74 kg/m^2 and 1.64 kg/m^2 respectively by 16 years. There were no statistically significant BMI differences between the White UK girls and the Indian and Pakistani/Bangladeshi girls at any age. It is important to note that in early adolescence this lower BMI group still had BMIs which were almost 0.5 SD higher than the reference population; therefore they had a low mean BMIs compared to the Nigerian/Ghanaians, Black Caribbeans and Other Africans but not compared to the reference population.

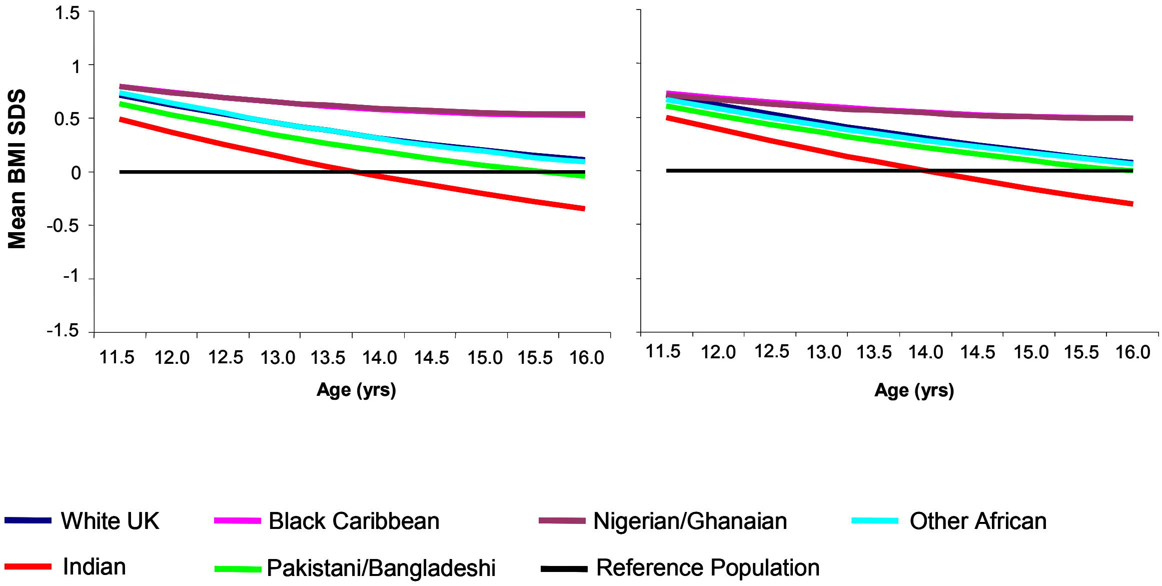
Figure 3.13 Boys: Predicted BMI by age
(a) BMI (kg/m^2)[1]

Null **Baseline**



(b) BMI SDS[2]

Null **Baseline**



[1]BMI

Null Model: ethnicity*age, age^2

Baseline model: ethnicity*age, age^2, pubertal status, height

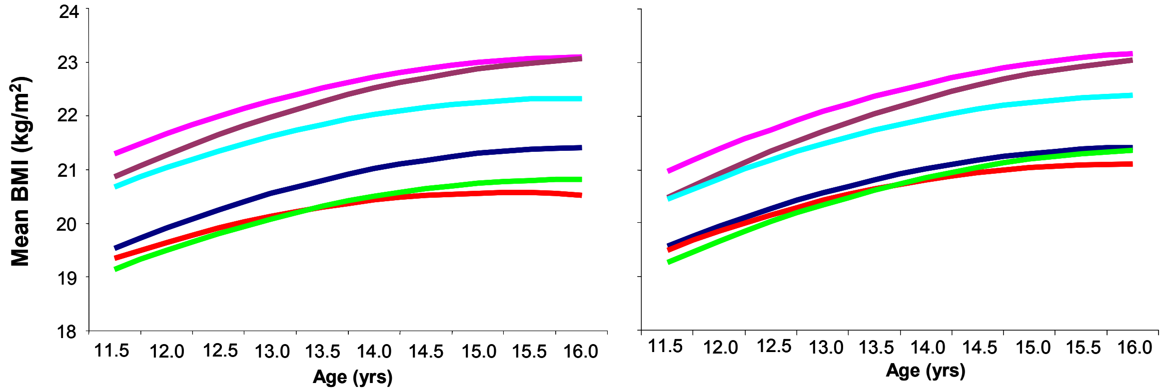
[2]BMI SDS

Null Model: ethnicity*age, age^2

Baseline Model: ethnicity*age, age^2, pubertal status*age, height

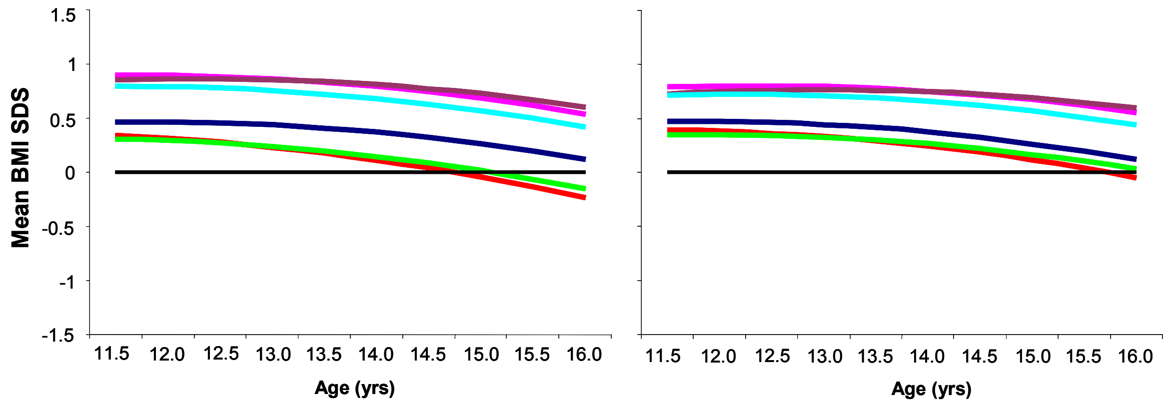
Figure 3.14 Girls: Predicted BMI by age
(a) BMI (kg/m²) [1]

Null | **Baseline**



(b) BMI SDS [2]

Null | **Baseline**



White UK | Black Caribbean | Nigerian/Ghanaian | Other African
Indian | Pakistani/Bangladeshi | Reference Population

[1]BMI

Null Model: ethnicity*age, age^2

Baseline model: ethnicity*age, age^2, height SDS, pubertal status

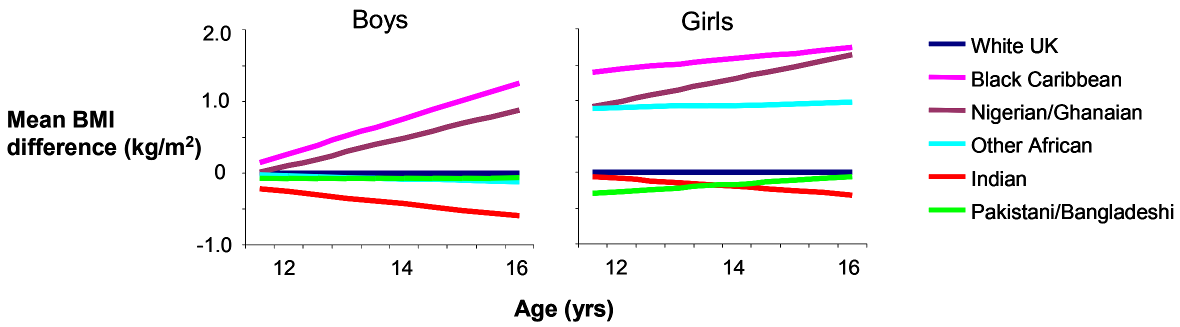
[2]BMI SDS

Null Model: ethnicity*age, age^2

Baseline Model: ethnicity*age, age^2, height SDS, pubertal status

Figure 3.15 Ethnic differences in mean BMI compared to White UK by age

(adjusted for pubertal status and height)



3.3.4 BMI - Key Points

- All ethnic groups had a high mean BMI relative to the reference population in early adolescence.

- SD scores declined with increasing age in all ethnic groups, but remained high relative to the reference population for Black Caribbean and Nigerian/Ghanaian boys and girls and Other African girls.

- Among girls, ethnic differences in BMI were already apparent at 11.5yrs and these persisted with increasing age; Black Caribbean, Nigerian/Ghanaian, and Other African girls had the highest mean BMIs.

- Among boys, ethnic differences in BMI emerged between 11.5 and 16yrs; the Black Caribbean boys had significantly higher BMIs than their White peers from 13.5yrs and the Nigerian/Ghanaians from 15yrs.

- There was a notable sex difference for the Other African group: the girls had significantly higher BMIs than their White UK peers whereas the boys had BMIs very similar to the White UK and Pakistani/Bangladeshi boys.

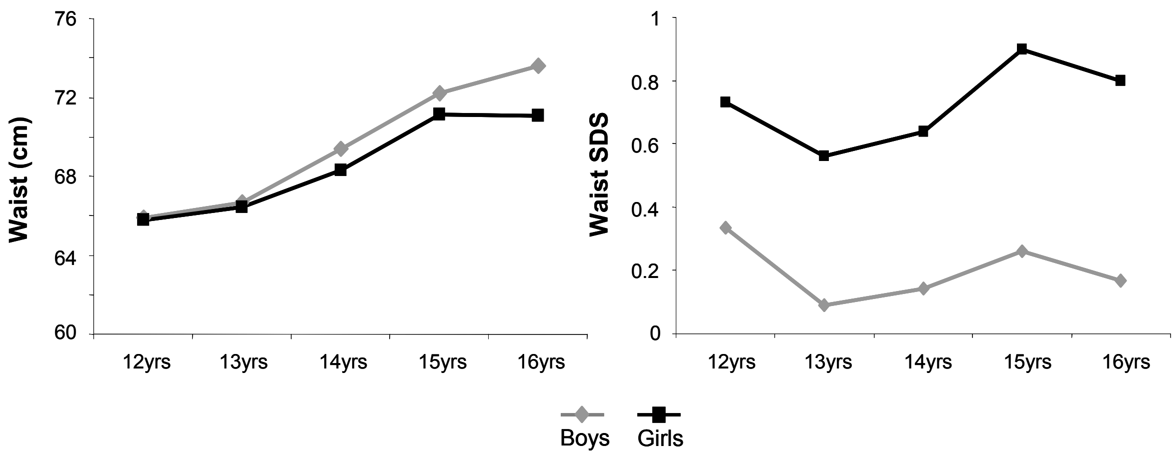
- Pubertal status and height were significantly related to BMI; they attenuated but did not fully explain the ethnic differences observed.

3.4 Waist Circumference

3.4.1 Overall trends in waist circumference

Boys' and girls' waist circumferences were similar at 12 and 13yrs (Figure 3.16). After this, the boys' waists increased more than the girls'. Similar to height, weight, and BMI, there was no mean increase in waist for girls between 15 and 16yrs. The girls' SD scores were higher than the boys at all ages, however the shape of the trend was consistent for both sexes; both decreased from 12 to 13yrs then increased to a peak at 15yrs before decreasing again. This is a different pattern to that observed for height, weight and BMI SD scores. The girls' mean waist SD score at 16yrs was slightly higher than at 12yrs despite the decline from 15-16 years.

Figure 3.16 Comparison of boys and girls mean waist circumferences by age
(a) Mean waist (cm) **(b) Mean waist (SDS)**



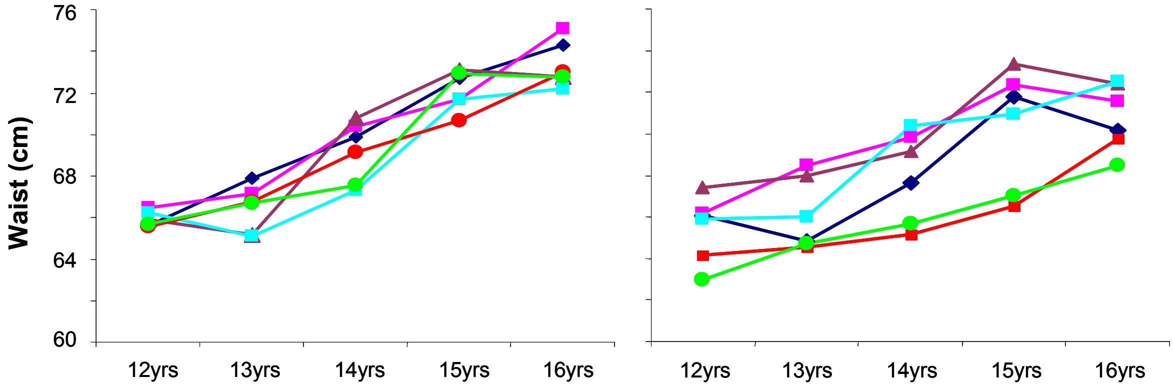
3.4.2 Ethnic differences in waist circumference trends

Ethnic differences were already apparent at 12yrs for the girls but not the boys (Figure 3.17). Between 12 and 16yrs there was no clear ethnic pattern for the boys i.e. no one group consistently had the largest or smallest waist. At 16yrs the Black Caribbeans and White UK boys had the largest waists. For the girls, the Black Caribbean, Nigerian/Ghanaian, and Other Africans tended to have the largest waists and the Indians and Pakistani/Bangladeshis the smallest. It is striking that at 16yrs, compared to their peers, the Other African boys had the smallest waists but the Other African girls the largest.

The trends in waist SD score differed by ethnic group (Figure 3.17b). For example, the mean SD scores of the Pakistani/Bangladeshi girls and the Black Caribbean boys hardly changed with age. In contrast, other groups had a relatively large decline followed by an incline (e.g. the Nigerian/Ghanaian boys and the White UK girls). What is evident however is that all of the girls had waists larger than the reference population at all ages (even the Pakistani/Bangladeshi girls had a waist SD of around 0.25; by way of comparison, this value would place them in the top 3 of the boys' groups). Therefore compared to the reference population, even groups who were lighter and shorter had larger waist circumferences.

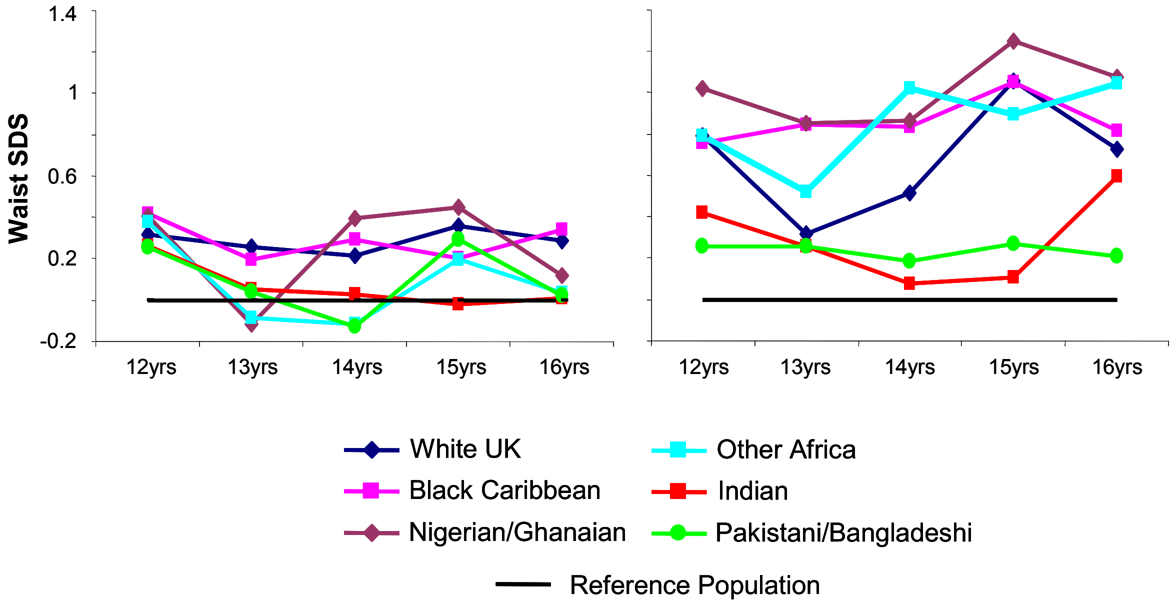
Figure 3.17 Mean waist circumference by ethnicity and age
(a) Waist in centimetres

Boys **Girls**



(b) Waist SDS

Boys **Girls**



For both genders, those in late puberty had larger waists than those in early/mid puberty. There were no significant ethnic differences in mean difference in waist circumference between those in early/mid and late puberty at either age (Table 3.11).

Table 3.11 Difference in mean waist between those in early/mid and late puberty by sex, age and ethnic group

	Age (yrs)	Difference in mean waist between those in early/mid vs. late puberty (cm) [1]					
		White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys	11-13	1.44	1.18	2.78	1.24	3.04	-0.36
	14-16	5.15	4.71	1.57	4.45	5.63	1.25
Girls	11-13	2.78	2.86	2.58	2.47	0.28	2.83
	14-16	1.34	5.38	1.79	3.44	3.91	4.38

[1]Calculated as mean waist in late puberty minus mean waist in early/mid puberty

For boys, at 11-13yrs and adjusting only for age, there were no significant ethnic differences in waist circumference (Table 3.12). However significant ethnic differences emerged with the addition of height SDS to the models; as the Black Caribbean, Nigerian/Ghanaian and Other African boys were significantly taller than the White UK boys at this age, their waist circumferences were significantly smaller than their White UK peers after adjustment for height. Once BMI was adjusted for, the Black Caribbeans, Nigerian/Ghanaians, and Other Africans, all had waists significantly smaller than the White UK boys at both 11-13yrs and 14-16yrs.

There were already significant ethnic differences for girls at 11-13yrs. Adjusting only for age; the Black Caribbean and Nigerian/Ghanaian girls had significantly larger waists than the White UK girls (Table 3.13). Adjustment for pubertal status explained a small amount of the excess, however adjustment for height had a much greater impact; coefficients were reduced and no significant ethnic differences remained. Before the addition of BMI to the model, all of the ethnic groups had a mean waist greater than the White UK girls, however once BMI was adjusted for all of the groups had a mean waist less than the White UK girls. Of note, once BMI was adjusted for the Black Caribbean girls had the lowest mean waist circumference of all the groups, and this was significantly lower than the White UK girls. At 14-16yrs the differences in waist circumference between the White UK and the Black Caribbean, Nigerian/Ghanaian, and Other African girls were only significant once BMI was included in the model. The Indian and Pakistani/Bangladeshi girls had waists significantly smaller than the White UK girls when only age was adjusted for; however once height was added to the model the differences between these groups and the White

UK girls were no longer significant; the Indian and Pakistani/Bangladeshi girls' shorter stature was associated with their smaller waists. Pubertal status was a significant correlate independent of height for girls but not boys. Height and BMI were positively associated with waist circumference for both genders.

Table 3.12 Boys: Ethnic differences in waist at 11-13yrs and 14-16yrs

	11-13 yrs[1]				14-16 yrs[1]			
	Age[2]	+Puberty[3]	+Height[4]	+BMI[5]	Age[2]	+Puberty[3]	+Height[4]	+BMI[5]
Waist (cm)								
Ethnicity (Ref: White UK)								
Black Caribbean	0.10	-0.07	-1.01	-1.29*	-0.30	-0.37	-0.45	-2.74*
Nigerian/Ghanaian	-1.13	-1.18	-2.43*	-1.90*	-0.31	-0.32	-0.80	-2.30*
Other African	-1.25	-1.28	-2.27*	-1.72*	-1.90*	-1.84*	-1.93*	-1.65*
Indian	-0.51	-0.37	0.14	0.32	-1.74*	-1.61	-0.46	0.40
Pakistani/Bangladeshi	-0.30	-0.25	-0.19	-0.17	-1.05	-0.95	0.08	0.01
Age (yrs)	1.02*	0.84*	1.39*	0.87*	1.34*	1.14*	1.78*	0.79*
Puberty (Late vs. Early/mid)		1.31*	-0.49	-0.44*		3.02*	0.85	-1.50*
Height (SDS)			3.63*	1.40*			3.05*	1.61*
BMI				2.01*				2.29*
Waist SDS								
Ethnicity (Ref: White UK)								
Black Caribbean	0.01	-0.02	-0.16	-0.20*	-0.06	-0.07	-0.08	-0.34*
Nigerian/Ghanaian	-0.11	-0.12	-0.31*	-0.23*	0.02	0.02	-0.05	-0.22*
Other African	-0.17	-0.17	-0.33*	-0.24*	-0.24*	-0.23*	-0.24*	-0.21*
Indian	-0.17	-0.15	-0.08	-0.05	-0.33*	-0.31*	-0.15	-0.06
Pakistani/Bangladeshi	-0.11	-0.10	-0.09	-0.09	-0.20*	-0.19	-0.04	-0.05
Age (yrs)	-0.20*	-0.23*	-0.14*	-0.21*	-0.12*	-0.15*	-0.06	-0.18*
Puberty (Late vs. Early/mid)		0.23*	-0.05	-0.04		0.51*	0.20	-0.06
Height (SDS)			0.56*	0.26*			0.43*	0.26*
BMI				0.27*				0.26*

[1]Coefficients were estimated using linear regression models for 11-13yrs (Wave 1) and 14-16yrs (Wave 2)

[2]Model adjusted for ethnicity and age

[3]Model Adjusted for ethnicity, age and pubertal status

[4]Model Adjusted for ethnicity, age, pubertal status and height SDS

[5]Model Adjusted for ethnicity, age, pubertal status, height SDS, and BMI

*p<0.05 compared to reference

Table 3.13 Girls: Ethnic differences in waist at 11-13yrs and 14-16yrs

	11-13 yrs[1]				14-16 yrs[1]			
	Age[2]	+Puberty[3]	+Height[4]	+BMI[5]	Age[2]	+Puberty[3]	+Height[4]	+BMI[5]
Waist (cm)								
Ethnicity (Ref: White UK)								
Black Caribbean	2.21*	1.48*	0.68	-1.07*	1.09	0.77	0.75	-2.14*
Nigerian/Ghanaian	2.47*	1.65*	0.57	-0.23	1.53	1.15	0.79	-1.59*
Other African	1.37	0.92	0.26	-0.73	0.81	0.66	0.67	-0.87*
Indian	-1.27	-1.29	0.09	-0.14	-3.44*	-3.35*	-0.97	-0.17
Pakistani/Bangladeshi	-1.51	-1.54	-0.47	-0.37	-3.07*	-2.95*	-0.73	-0.33
Age (yrs)	0.65	0.18	1.01*	0.01	0.49	0.36	0.78	0.47*
Puberty (Late vs. Early/mid)		2.21*	0.95*	-0.74*		3.07*	2.53*	-0.28
Height (SDS)			2.82*	1.34*			2.44*	1.77*
BMI				1.78*				1.97*
Waist SDS								
Ethnicity (Ref: White UK)								
Black Caribbean	0.30*	0.17	0.03	-0.22*	0.07	0.02	0.02	-0.38*
Nigerian/Ghanaian	0.42*	0.27*	0.09	-0.03	0.21	0.15	0.09	-0.23*
Other African	0.24	0.16	0.06	-0.09	0.10	0.07	0.07	-0.14*
Indian	-0.26*	-0.26*	-0.05	-0.07	-0.64*	-0.63*	-0.26	-0.16*
Pakistani/Bangladeshi	-0.25	-0.26	-0.09	-0.07	-0.61*	-0.59*	-0.25	-0.20*
Age (yrs)	-0.16*	-0.24*	-0.11	-0.25*	-0.04	-0.06	0.00	-0.04
Puberty (Late vs. Early/mid)		0.40*	0.20*	-0.04		0.51*	0.43*	0.05
Height (SDS)			0.46*	0.24*			0.37*	0.28*
BMI				0.26*				0.27*

[1]Coefficients were estimated using linear regression models for 11-13yrs (Wave 1) and 14-16yrs (Wave 2)

[2]Model adjusted for ethnicity and age

[3]Model Adjusted for ethnicity, age and pubertal status

[4]Model Adjusted for ethnicity, age, pubertal status and height SDS

[5]Model Adjusted for ethnicity, age, pubertal status, height SDS, and BMI

*p<0.05 compared to reference

3.4.3 Longitudinal waist circumference trends

The figures of the longitudinal trends for boys clearly illustrate the findings from the cross-sectional analysis; adjusting for height and pubertal status results in ethnic differences in waist actually increasing at the younger ages (Figure 3.18). This is in contrast to what was observed for weight and BMI, when there were no significant ethnic differences at this age once height was adjusted for. At 11.5yrs the Nigerian/Ghanaian (-2.81cm) and Other African (-1.92cm) boys had significantly smaller waists than the White UK boys (Figure 3.20). With increasing age, the difference between the Other Africans and White UK boys increased slightly. In contrast, the gap between the Nigerian/Ghanaians and the White UK boys narrowed considerably; by 14yrs the difference between them was no longer statistically significant. There were no significant ethnic differences between the other ethnic groups and the White UK boys at any age. The Black Caribbeans and Pakistani/Bangladeshis had smaller waists than the White UK boys at all time points. For the Black Caribbeans the difference remained fairly constant (ranging from -0.57cm at

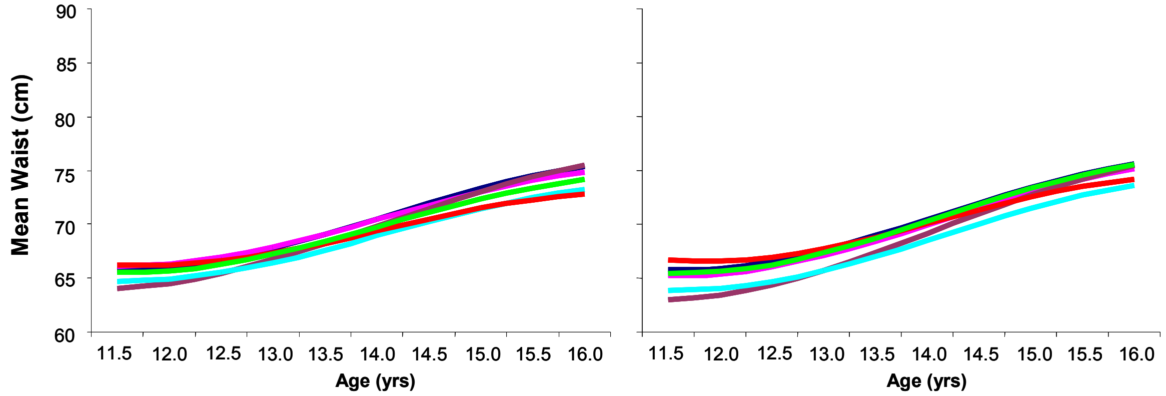
11.5yrs to -0.43cm at 16yrs), whereas for the Pakistani/Bangladeshis it narrowed (from -0.38cm to -0.05cm). The Indian boys had waists 0.87cm greater than the White UK boys at 11.5 years, however by 16 years they had waists 1.37cm smaller.

Relative to the reference population, all of the boys' ethnic groups had larger waists at the younger ages (Figure 3.18b). Although SD scores initially decreased slightly with increasing age, they then tended to increase again (with the exception of the Indian boys). The increase was particularly marked for the Nigerian/Ghanaian boys. After adjustment for height and pubertal status all groups had mean waists greater than the reference population at 16yrs. It is of note that the ranking of the groups by mean waist is different to that observed for BMI. For example, the White UK boys had the largest waists at 16yrs, followed by the Pakistani/Bangladeshi boys. In contrast these two groups had mean BMIs significantly lower than the Black Caribbean and Nigerian/Ghanaian boys. The Other Africans had the smallest mean waist but had a mean BMI the same as the White UK and Pakistani/Bangladeshi boys.

For girls, as was seen in the cross-sectional analysis, adjusting for pubertal status and height SDS markedly reduced the ethnic differences, and ethnic differences in waist (cm) remained constant across this age range after accounting for these factors (Figure 3.19a and Figure 3.20). None of the ethnic differences were statistically significant. At all ages every ethnic group had a mean waist circumference larger than the reference population (Figure 3.19b). There was no indication of the waist SD scores becoming closer to 0 with increasing age as was observed for height, weight and BMI.

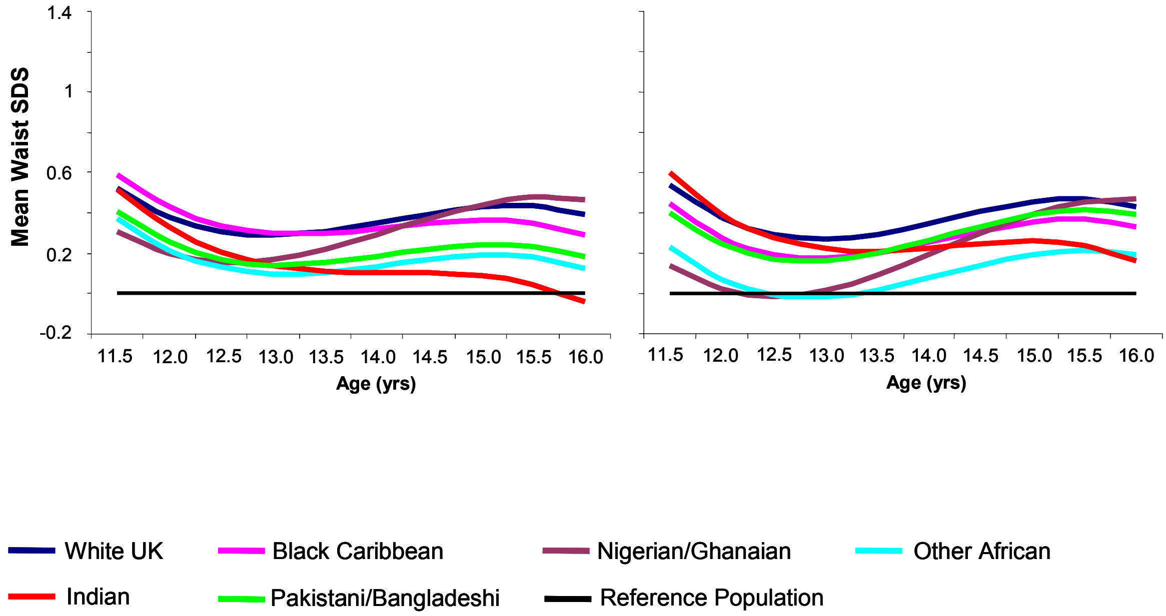
Figure 3.18 Boys: Predicted Waist Circumference by age
(a) Waist Circumference (cm)[1]

Null | **Baseline**



(b) Waist Circumference SDS [2]

Null | **Baseline**



[1]Waist (cm)

Null Model: ethnicity*age, age^2, age^3

Baseline model: ethnicity*age, age^2, age^3, pubertal status, height SDS

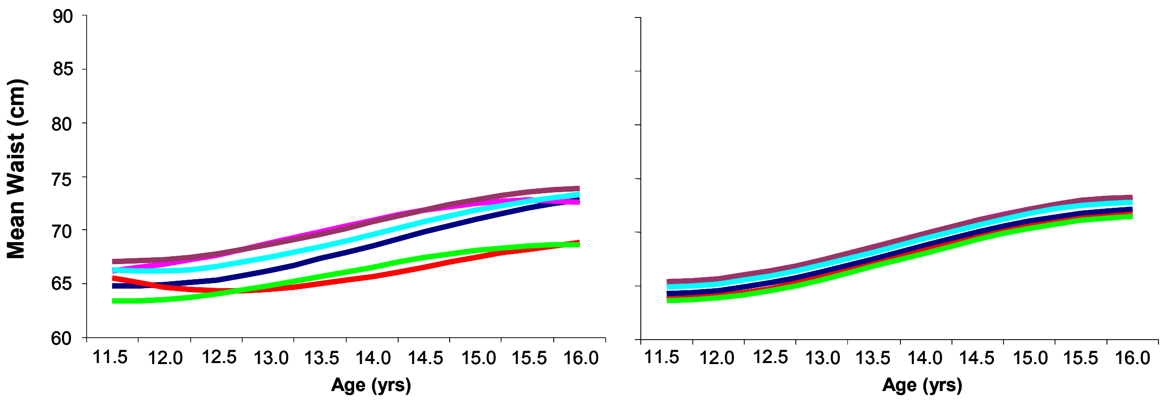
[2]Waist SDS

Null Model: ethnicity*age, age^2, age^3

Baseline Model: ethnicity*age, age^2, age^3, pubertal status*height SDS

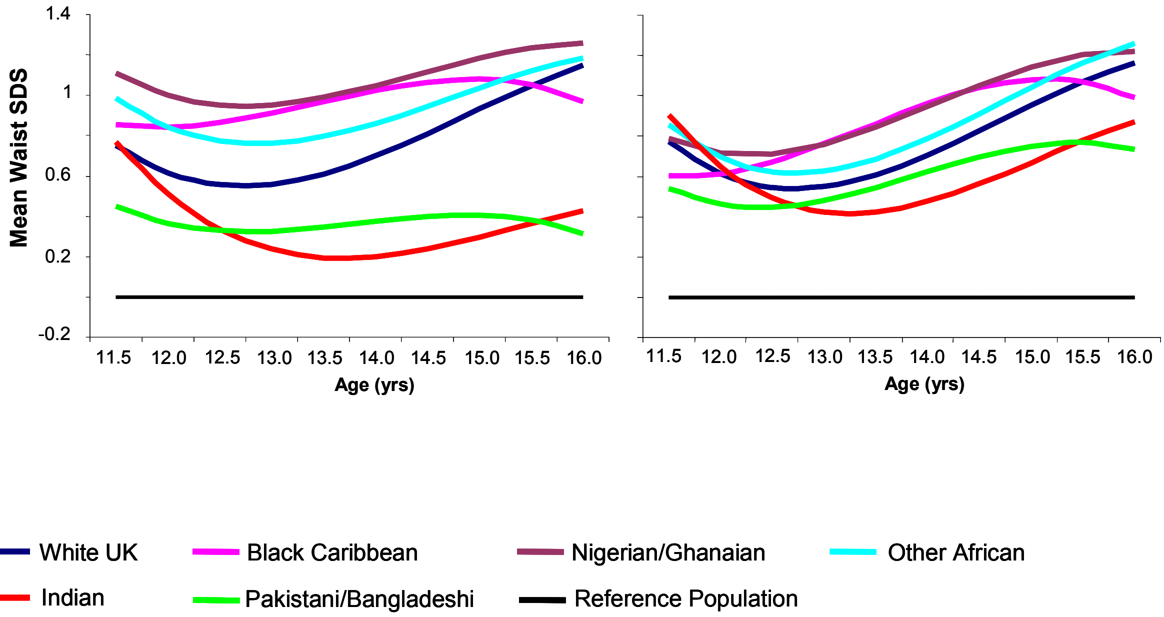
Figure 3.19 Girls: Predicted Waist Circumference by age
(a) Waist Circumference (cm) [1]

Null **Baseline**



(b) Waist Circumference SDS [2]

Null **Baseline**



[1]Waist (cm)

Null Model: ethnicity*age, ethnicity*age^2, age^3

Baseline model: ethnicity, pubertal status*age, age^2, age^3, height SDS

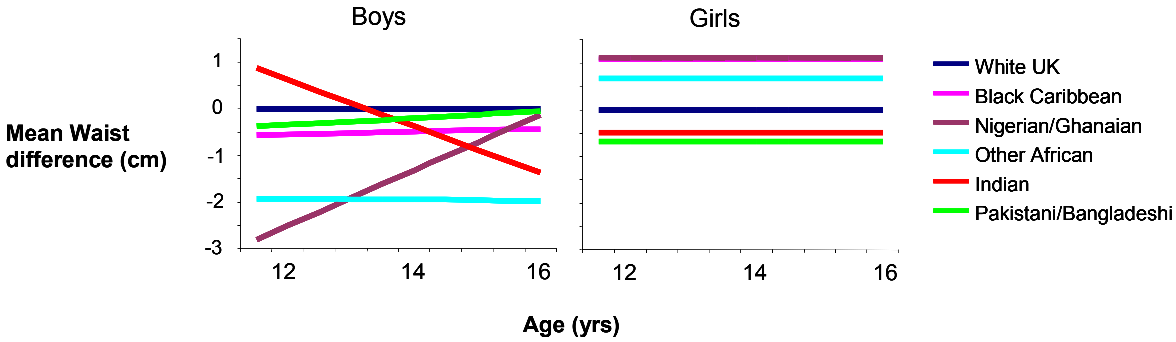
[2]Waist SDS

Null Model: ethnicity*age, ethnicity*age^2, age^3

Baseline Model: ethnicity*age, ethnicity*age^2, age^3, pubertal status, height SDS

Figure 3.20 Ethnic differences in mean waist (cm) compared to White UK by age

(adjusted for pubertal status and height)



3.4.4 Waist Circumference - Key points

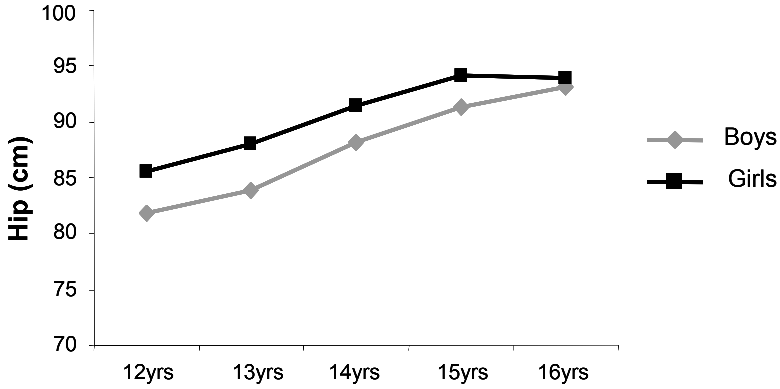
- Overall the DASH pupils had larger waists than the reference population across the entire age range; this was particularly true for the girls.
- There was no indication of the difference in waist size between the DASH pupils and the reference population declining in later adolescence as was observed for height, weight, and BMI.
- Adjustment for height and pubertal status resulted in there being no significant ethnic differences in waist circumference at any age for the girls.
- By contrast, adjustment for these factors increased ethnic differences at younger ages for the boys; the Other African boys had significantly smaller waist circumferences than the White UK boys at all ages, and the Nigerian/Ghanaians from 11.5 to 14yrs. There were no other significant ethnic differences.
- Further adjustment for BMI generally increased ethnic differences; at 14-16yrs the Black Caribbean, Nigerian/Ghanaian and Other African girls and boys had significantly smaller waists the their White UK peers.
- The ethnic patterns observed for waist circumference were not the same as those observed for BMI.

3.5 Hip Circumference

3.5.1 Overall trends in hip circumference

Girls had a larger mean hip circumference than boys at all ages but the sex difference decreased with increasing age. By 16 years both boys and girls had a similar mean hip circumference of approximately 93cm (Figure 3.21).

Figure 3.21 Trends in hip (cm) by age and sex

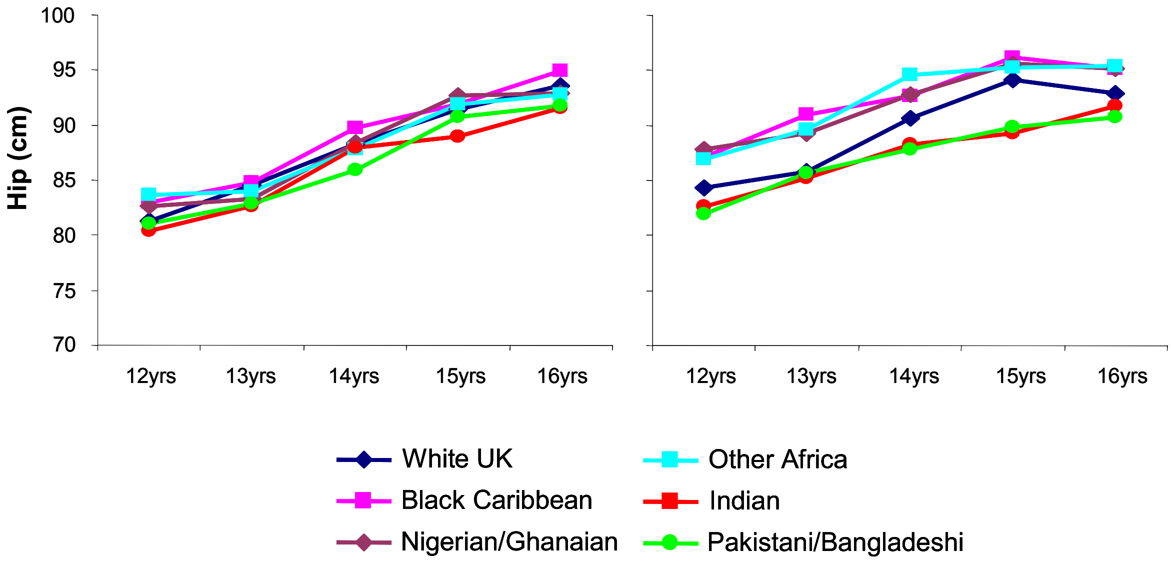


3.5.2 Ethnic differences in hip circumference trends

The ethnic differences in hip circumference were larger for the girls than the boys (Figure 3.22). The Black Caribbean, Nigerian/Ghanaian and Other African girls had the largest hips at all ages; however it was the White UK girls who had the largest increase in hip circumference between 13 and 15yrs. For both boys and girls, the Indians and Pakistani/Bangladeshis tended to have the smallest hip measurements at each age.

Figure 3.22 Trends in hip (cm) by age and ethnicity

(a) Boys **(b) Girls**



Being in late puberty was associated with having a larger hip circumference for both boys and girls, and at both 11-13yrs and 14-16yrs (Table 3.14). Differences in hip circumference between early and late puberty tended to be slightly larger than those observed for waist.

Table 3.14 Difference in mean hip between those in early/mid and late puberty by sex, age and ethnic group

	Age (yrs)	Difference in mean hip between those in early/mid vs. late puberty (cm) [1]					
		White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys	11-13	2.72	1.43	4.48	0.80	5.12	0.85
	14-16	6.68	4.91	4.79	5.17	6.69	3.64
Girls	11-13	4.87	5.10	5.31	4.50	2.88	4.35
	14-16	3.34	5.84	4.03	3.58	5.18	2.75

[1] Calculated as mean hip in late puberty minus mean hip in early/mid puberty

For the boys, none of the ethnic groups had hip circumferences significantly different from the White UK boys at 11-13yrs when adjusting for age, or age and pubertal status only (Table 3.15). Further adjustment for height resulted in the Nigerian/Ghanaian boys having a mean hip circumference significantly less than the White UK boys. The Black Caribbean boys also had significantly smaller hips than the White UK boys once BMI was also included in the model. Conversely, adjustment for BMI reduced the difference between the Nigerian/Ghanaian and White UK boys but it remained significant. At 14-16yrs and adjusting only for age, the Indian and Pakistani/Bangladeshi boys had significantly smaller hips than the White UK boys. However, once height and pubertal status were adjusted for, the hips of these groups were no longer smaller. With the addition of BMI to the model, the Black Caribbeans and Nigerian/Ghanaians had significantly smaller hips than the White UK boys. As at 11-13 years, once BMI was adjusted for, it was again the Nigerian/Ghanaian boys who had the smallest mean hip circumference, although the difference between them and the Black Caribbeans was much smaller at 14-16yrs than it was at 11-13yrs.

For girls at 11-13 years and adjusting only for age, the Black Caribbean, Nigerian/Ghanaian, and Other African girls all had hips significantly larger than the White UK girls (Table 3.16). Adjustment for pubertal status and height accounted for the greater hip size of the Nigerian/Ghanaian girls. In contrast, although attenuated, the significant differences remained for the Black Caribbean and Other African girls. After adjustment for height, the Indian girls also had significantly larger hips than the White UK girls. In the final model, adjusting for BMI, the Other Africans and Indians both had mean hips just over 1cm larger than the White UK girls; a statistically significant difference. The Black Caribbeans no longer had bigger hips; their larger size was associated with their greater BMI. At 14-16yrs adjusting only for age, the Black Caribbeans and Nigerian/Ghanaians had significantly larger hips than the White UK girls and their hips remained significantly larger after adjustment for pubertal status and height (although ethnic differences were reduced). The Indians and Pakistani/Bangladeshis no longer had significantly smaller hips after adjustment for height and pubertal status.

Pubertal status remained a significant correlate of hip circumference after adjustment for height at 11-13yrs and 14-16yrs for girls (Table 3.16), but only 11-13yrs for boys (Table 3.15). Height was positively correlated with hip circumference for both sexes at both ages. BMI attenuated the relationship between height and hip circumference but height remained significant for both boys and girls. BMI itself was also a significant correlate, with a very similar effect size at both ages.

Table 3.15 Boys: Ethnic differences in hip at 11-13yrs and 14-16yrs

	11-13 yrs[1]				14-16 yrs[1]			
	Age[2]	+Puberty[3]	+Height[4]	+BMI[5]	Age[2]	+Puberty[3]	+Height[4]	+BMI[5]
Ethnicity (Ref: White UK)								
Black Caribbean	1.11	0.84	-0.36	-0.62*	0.88	0.78	0.67	-1.30*
Nigerian/Ghanaian	0.01	-0.07	-1.69*	-1.19*	0.51	0.48	-0.14	-1.39*
Other African	0.87	0.82	-0.42	0.17	-0.29	-0.20	-0.31	-0.03
Indian	-0.96	-0.70	0.03	-0.25	-2.27*	-2.06*	-0.55	0.14
Pakistani/Bangladeshi	-0.63	-0.51	-0.37	-0.30	-1.52*	-1.36*	-0.03	-0.09
Age (yrs)	2.37*	2.07*	2.78*	0.12*	2.17*	1.86	2.66*	1.81*
Puberty (Late vs. Early/mid)		2.09*	-0.27	0.15		4.68*	1.88*	-0.11
Height (SDS)			4.79*	2.65*			3.92*	2.70*
BMI				1.94*				1.97*

[1]Coefficients were estimated using linear regression models for 11-13yrs (Wave 1) and 14-16yrs (Wave 2)

[2]Model adjusted for ethnicity and age

[3]Model Adjusted for ethnicity, age and pubertal status

[4]Model Adjusted for ethnicity, age, pubertal status and height SDS

[5]Model Adjusted for ethnicity, age, pubertal status, height SDS, and BMI

*p<0.05 compared to reference

Table 3.16 Girls: Ethnic differences in hip at 11-13yrs and 14-16yrs

	W1 (11-13 yrs)[1]				W2 (14-16 yrs)[1]			
	Age[2]	+Puberty[3]	+Height[4]	+BMI[5]	Age[2]	+Puberty[3]	+Height[4]	+BMI[5]
Ethnicity (Ref: White UK)								
Black Caribbean	4.17*	2.83*	1.70*	-0.31	1.99*	1.60*	1.64*	-1.13*
Nigerian/Ghanaian	3.57*	2.06*	0.47	-0.56	1.52*	1.06	0.70*	-1.64*
Other African	3.97*	3.14*	2.28*	1.02*	1.59	1.42	1.52	-0.03
Indian	-0.93	-0.98	1.23*	1.03*	-3.54*	-3.43*	-0.53	0.16
Pakistani/Bangladeshi	-1.32	-1.37	0.48	0.51	-3.28*	-3.13*	-0.40	-0.05
Age (yrs)	2.84*	2.00*	3.27*	2.12*	0.77*	0.61	1.13*	0.82*
Puberty (Late vs. Early/mid)		3.94*	2.00*	0.17		3.77*	3.12*	0.49*
Height (SDS)			4.38*	2.78*			2.92*	2.30*
BMI				1.91*				1.81*

[1]Coefficients were estimated using linear regression models for 11-13yrs (Wave 1) and 14-16yrs (Wave 2)

[2]Model adjusted for ethnicity and age

[3]Model Adjusted for ethnicity, age and pubertal status

[4]Model Adjusted for ethnicity, age, pubertal status and height SDS

[5]Model Adjusted for ethnicity, age, pubertal status, height SDS, and BMI

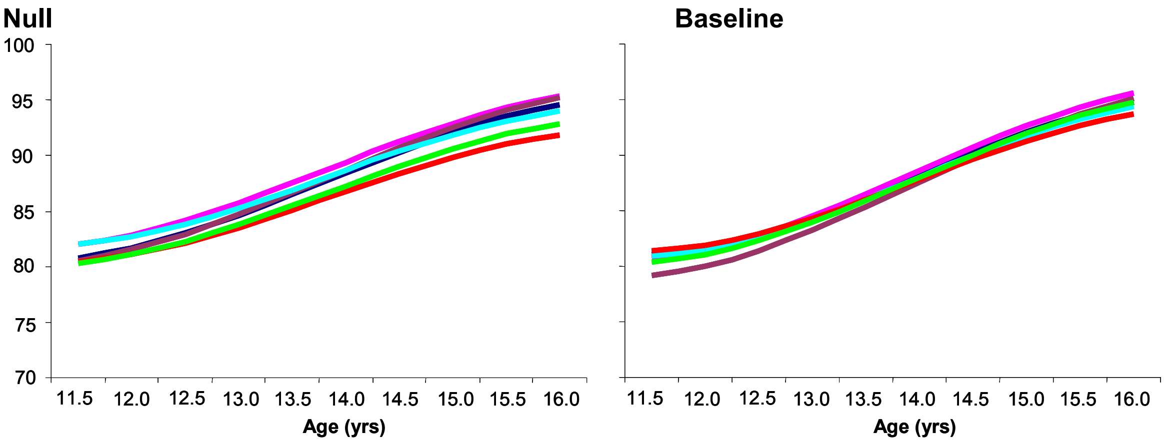
*p<0.05 compared to reference

3.5.3 Longitudinal hip circumference trends

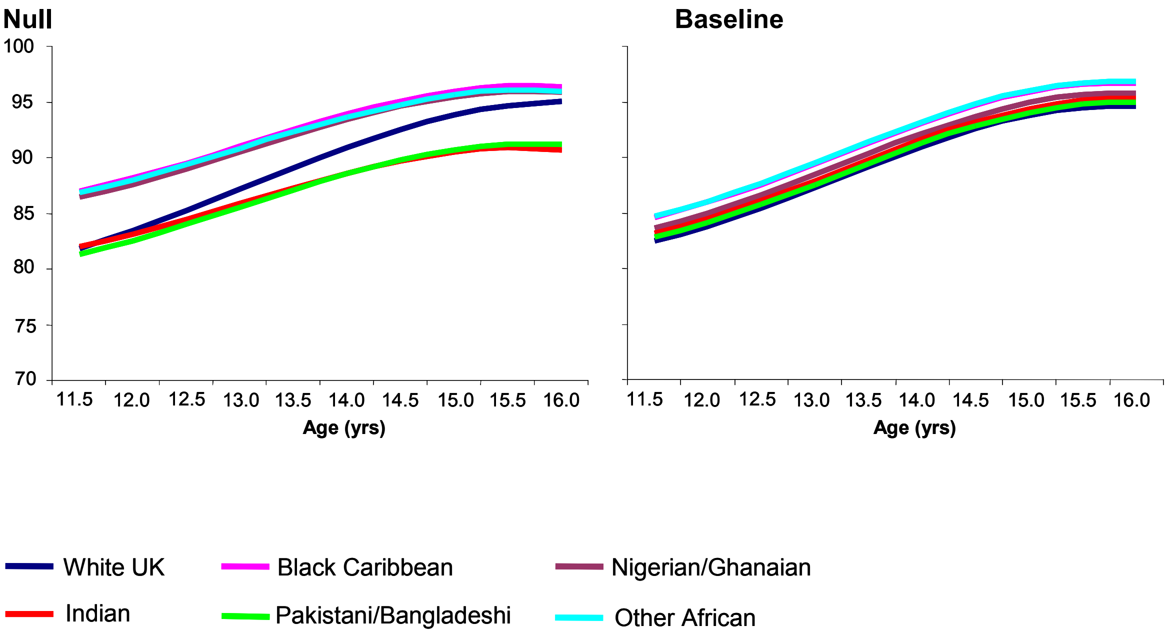
The figures highlight the slight increase in the ethnic differences in hip circumferences for the boys as age increases (Figure 3.23a). Adjustment for height and pubertal status had two effects; firstly, it reduced the ethnic differences in hip circumference, particularly at the older ages. Secondly, the ranking of the ethnic groups changed at the younger ages; after adjustment the Indian boys had the largest hips and the Nigerian/Ghanaians the smallest. After adjustment, the Nigerian/Ghanaians had significantly smaller hips than the White UK boys at 11.5yrs (-1.91cm) but with increasing age the difference between these groups decreased so that by 13yrs it was no longer significant and by 15.5yrs these two groups had similar mean hip circumferences (Figure 3.24). By 16yrs the Indians had hips -0.6cm smaller and the Black Caribbeans 0.48cm larger than the White UK boys. However none of the other groups were significantly different from the White UK boys at this age.

The ethnic differences in the girls' hip trends were very different to the boys. There were clear ethnic disparities at the youngest ages (Figure 3.23b). These figures emphasise that the pace of hip growth was very similar in all groups (almost parallel lines), with the exception of the White UK girls for whom the pace of growth was considerably greater than that of the others. The clustering of the ethnic groups into two hip size groups at 16yrs was the same as that observed for height; the White UK, Black Caribbeans, Nigerian/Ghanaians and Other Africans in the larger hip group and the Indians and Pakistani/Bangladeshis in the smaller hip group. Adjustment for pubertal status and height reduced the girls' ethnic differences considerably, such that the pace of growth appeared uniform across all groups (therefore the faster hip growth of the White UK girls was explained by the fact that they also had faster height growth). In these adjusted results, at all ages compared to the White UK girls, hips were significantly larger among the Black Caribbeans (2.12cm) and Other Africans (2.23cm). Indeed the White UK girls had the smallest hips of all the groups (Figure 3.24). As there were no external reference data with which to produce SD scores, it is not possible to comment on how these trends compare with a reference population.

Figure 3.23 Predicted Hip Circumference (cm) by age
(a) Boys[1]



(b) Girls[2]



[1]Hip (cm) - Boys

Null Model: ethnicity*age, age^2, age^3

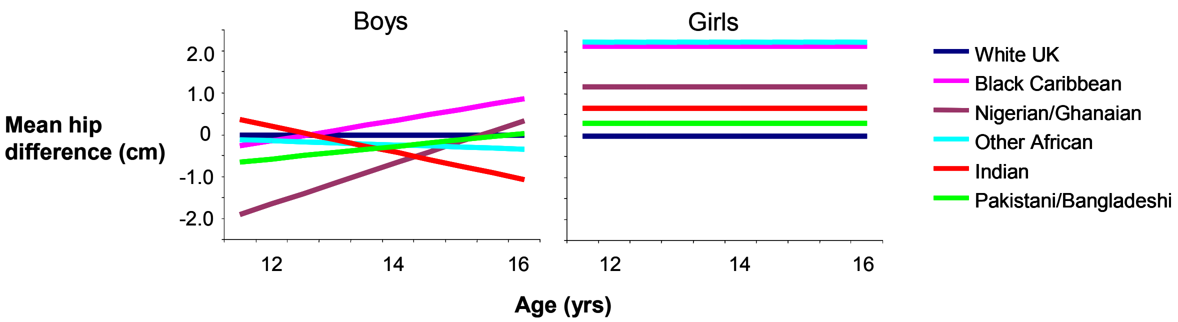
Baseline model: ethnicity*age, age^2, age^3, pubertal status, height SDS

[2]Hip (cm) - Girls

Null Model: ethnicity*age, age^2, age^3

Baseline model: ethnicity, age, age^2, age^3, pubertal status*height SDS

Figure 3.24 Ethnic differences in mean hip (cm) compared to White UK by age
(adjusted for pubertal status and height)



3.5.4 Hip Circumference - Key Points

- Pubertal status and height were significant correlates of hip circumference; controlling for them reduced ethnic differences, particularly for the girls.

- Pubertal status and height explained the greater increase in the White UK girls' hip circumference relative to the other girls.

- There was only one significant ethnic difference for the boys; after adjustment for height and pubertal status the Nigerian/Ghanaian boys had significantly smaller hips than the White UK boys up to the age of 13yrs.

- After adjustment for height and pubertal status, the White UK girls had the smallest hips. The Black Caribbean and Nigerian/Ghanaian girls had significantly larger hips than the White UK girls at all ages.

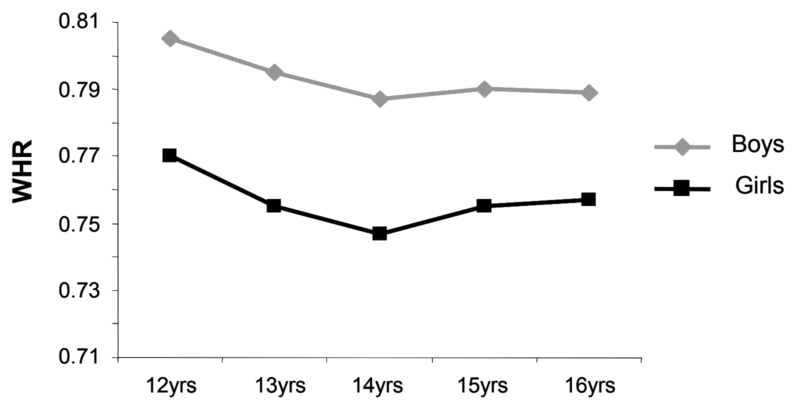
- Further adjustment for BMI resulted in a complete change in the ethnic pattern; Black Caribbean and Nigerian/Ghanaian boys at 11-13yrs and 14-16yrs, and girls at 14-16yrs, had significantly *smaller* hips than their White UK peers. Conversely, the Other African and Indian girls at 11-13yrs had significantly larger hips.

3.6 Waist-Hip Ratio (WHR)

3.6.1 Overall trends in WHR

Girls' mean WHR was less than boys' at all ages. The general trend for both sexes was the same; mean WHR gradually decreased with increasing age from 12 to 14 years then levelled-off (Figure 3.25).

Figure 3.25 Comparing trends in WHR for boys and girls

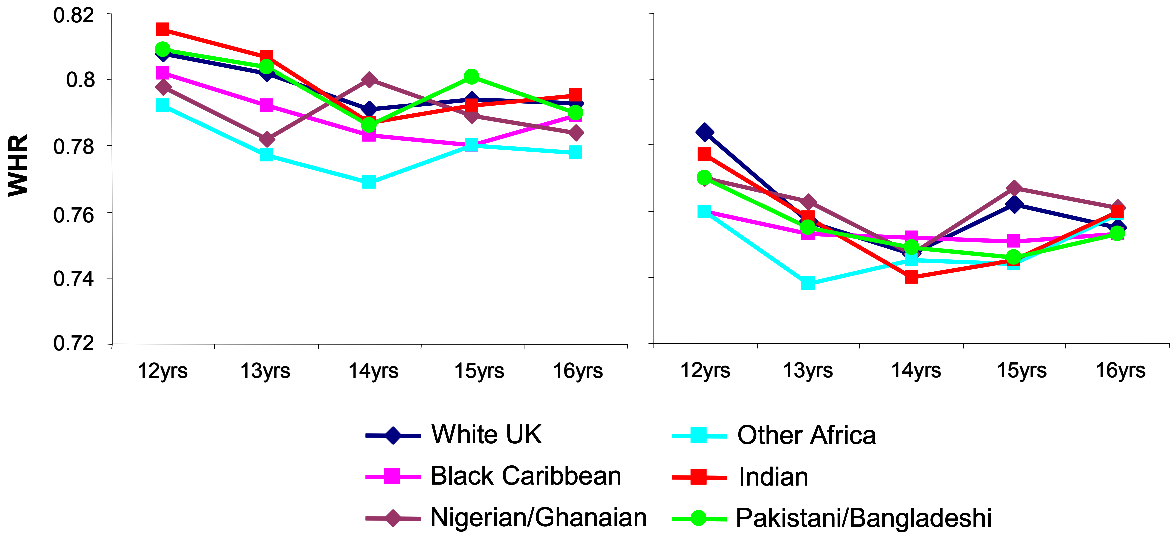


3.6.2 Ethnic differences in WHR

For the boys, at most ages the Indian and Pakistani/Bangladeshis had among the highest, and the Other Africans the lowest, WHR. Ethnic differences for the girls were larger at 12 years than at 16 years (Figure 3.26). At 12 years, the White UK girls had the highest ratios and the Other Africans the lowest. However by 16 years there was little difference between the groups.

Figure 3.26 Trends in WHR by age and ethnicity

(a) Boys **(b) Girls**



There was virtually no difference in WHR between those in early/mid puberty and late puberty at either 11-13yrs or 14-16yrs in any of the ethnic groups (Table 3.17).

Table 3.17 Difference in mean WHR between those in early/mid and late puberty by sex, age and ethnic group

	Age (yrs)	Difference in mean WHR between those in early/mid vs. late puberty [1]					
		White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys	11-13	-0.01	0.00	-0.01	0.01	-0.01	-0.01
	14-16	0.00	0.01	-0.03	0.00	0.00	-0.02
Girls	11-13	-0.01	-0.01	-0.02	-0.01	-0.02	-0.01
	14-16	-0.01	0.01	-0.02	0.01	0.00	0.02*

[1]Calculated as mean WHR in late puberty minus mean WHR in early/mid puberty

*Significantly difference to White UK value, $p<0.05$

The coefficients of the ethnic differences, and for the other covariates, in the WHR models were extremely small (0.02 or less) for both boys (Table 3.18) and girls (Table 3.19). Although some of the associations were statistically significant, the effect sizes were almost 0. For example, for boys at 11-13yrs the Black Caribbeans, Nigerian/Ghanaians, and Other Africans all had WHRs significantly less than the White UK boys but this difference was only -0.01 or -0.02. Therefore although there were often sizeable ethnic differences in both waist and hip circumferences, this was not seen in the WHR; the groups with the larger waists also had the larger hips. As with ethnicity, the associations between

WHR and age, pubertal status, height SDS, and BMI were sometimes significant but always small.

Table 3.18 Boys: Ethnic differences in WHR at 11-13yrs and 14-16yrs

	11-13 yrs[1]				14-16 yrs[1]			
	Age[2]	+Puberty[3]	+Height[4]	+BMI[5]	Age[2]	+Puberty[3]	+Height[4]	+BMI[5]
Ethnicity (Ref: White UK)								
Black Caribbean	-0.01*	-0.01*	-0.01*	-0.01*	-0.01*	-0.01*	-0.01*	-0.02*
Nigerian/Ghanaian	-0.01*	-0.01*	-0.01*	-0.01*	-0.01	-0.01	-0.01	-0.01*
Other African	-0.02*	-0.02*	-0.02*	-0.02*	-0.02*	-0.02*	-0.02*	-0.02*
Indian	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	0.00
Pakistani/Bangladeshi	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00
Age (yrs)	-0.01*	-0.01*	-0.01*	-0.01*	-0.00*	-0.00	-0.00	-0.01*
Puberty (Late vs. Early/mid)		-0.00	-0.00	-0.00		-0.01	-0.01	-0.01*
Height (SDS)			-0.00*	-0.01			-0.00	-0.01*
BMI				0.01*				-0.01*

Table 3.19 Girls: Ethnic differences in WHR at 11-13yrs and 14-16yrs

	11-13 yrs[1]				14-16 yrs[1]			
	Age[2]	+Puberty[3]	+Height[4]	+BMI[5]	Age[2]	+Puberty[3]	+Height[4]	+BMI[5]
Ethnicity (Ref: White UK)								
Black Caribbean	-0.01*	-0.01*	-0.01	-0.01*	-0.00	-0.01	-0.01	-0.01*
Nigerian/Ghanaian	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00
Other African	-0.02*	-0.02*	-0.01*	-0.02*	-0.00	-0.00	-0.00	-0.01*
Indian	-0.01	-0.01	-0.01*	-0.01*	-0.01	-0.01	-0.01	-0.00
Pakistani/Bangladeshi	-0.01	-0.01	-0.01	-0.01*	-0.01	-0.01	-0.01	-0.00
Age (yrs)	-0.02*	-0.01*	-0.02*	-0.02	-0.00	-0.00	-0.00	-0.00
Puberty (Late vs. Early/mid)		-0.01*	-0.01*	-0.01*		0.00	0.00	-0.01
Height (SDS)			-0.01*	-0.01*			0.00	0.00
BMI				0.00*				0.01*

[1]Coefficients were estimated using linear regression models for 11-13yrs (Wave 1) and 14-16yrs (Wave 2)

[2]Model adjusted for ethnicity and age

[3]Model Adjusted for ethnicity, age and pubertal status

[4]Model Adjusted for ethnicity, age, pubertal status and height SDS

[5]Model Adjusted for ethnicity, age, pubertal status, height SDS, and BMI

*p<0.05 compared to reference

3.6.3 Longitudinal Waist-Hip Ratio (WHR) trends

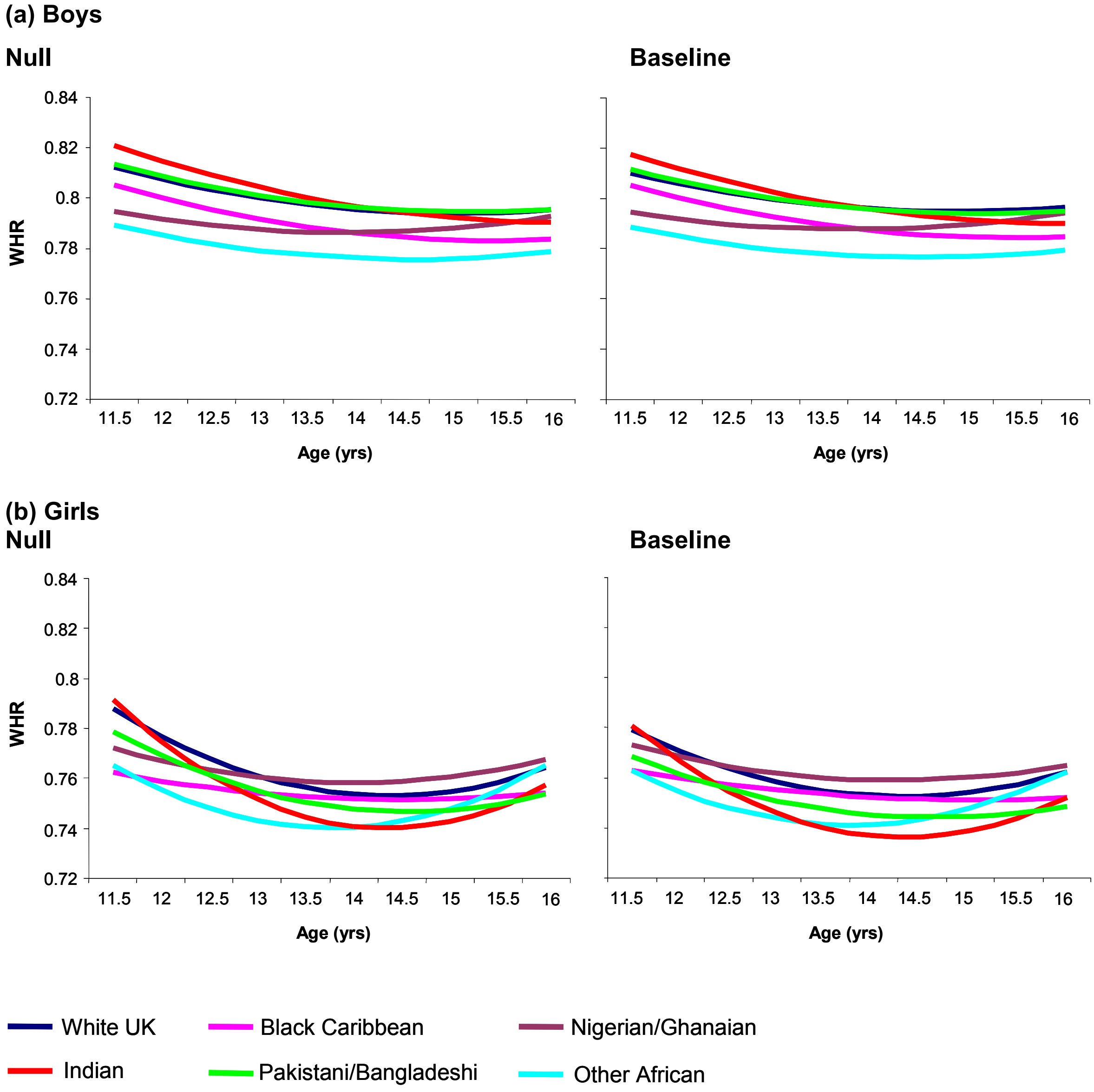
For boys, mean WHR gradually declined with increasing age in most ethnic groups, with this decline being steepest at the younger ages (Figure 3.27). The exception to this was the Nigerian/Ghanaians whose WHR, after an initial decline, gradually increased from around 14yrs; by 16yrs the mean value was very similar to that observed at 11.5yrs.

Although the magnitude of the ethnic differences in WHR was small, there were statistically significant differences. For boys, the Other Africans had the lowest mean WHR at all ages; this was consistently significantly lower than the White UK boys, although the difference between these groups gradually declined with increasing age (from

-0.022 at 11.5yrs to -0.017 at 16yrs) (Figure 3.28). The Nigerian/Ghanaian boys also had significantly lower WHRs at the youngest ages but from 14.5yrs, although their WHRs remained lower, the difference was no longer statistically significant. The difference between the White UK and Black Caribbean boys increased with increasing age; these groups were significantly different from each other from 13yrs onwards. By 16yrs, it was the Pakistani/Bangladeshi and White UK boys who had the highest mean WHR. Adjusting for height SDS and pubertal status did not have an impact on the ethnic trends.

The girls generally had lower WHRs than the boys; at the youngest ages the girls with the highest mean WHR (Indians and White UK) had mean values similar to the boys with the lowest WHR (Nigerian/Ghanaian and Other African) (Figure 3.27b). However among girls, by 16 years all groups had mean WHRs less than 0.78, whereas all groups among boys had values greater than 0.78 at this age. For girls, most groups had a decline in their WHR from 11.5yrs to around 14 yrs. This decline was steepest for the Indians who went from having the highest mean WHR at 11.5yrs to the lowest by 15yrs. From approximately 14yrs onwards, most groups had a slight increase in their WHR. However for the Other African girls there was a relatively steep increase, such that they went from having one of the lowest ratios at the younger ages to the second highest at 16yrs. The Black Caribbeans had relatively low mean WHRs at the youngest and oldest ages; however in the period in-between their values were more mid-ranking due to the fact that they did not experience the decline observed in the other groups at these ages. Adjustment for height SDS and pubertal stage made little difference to the ethnic differences; they were slightly reduced at the youngest ages and slightly widened at the older ages. As with the boys, absolute differences in WHR were extremely small but some were statistically significant. The Other African girls had significantly lower WHRs than the White UK from 11.5 to 14yrs, the Black Caribbeans from 11.5 to 12 yrs, and the Indians from 13 to 15.5yrs (Figure 3.28). By 16yrs none of the groups were significantly different from the White UK girls.

Figure 3.27 Predicted Waist-Hip-Ratio by age



[1]WHR - Boys

Null Model: ethnicity*age, age^2

Baseline model: ethnicity*age, age^2, pubertal status, height SDS

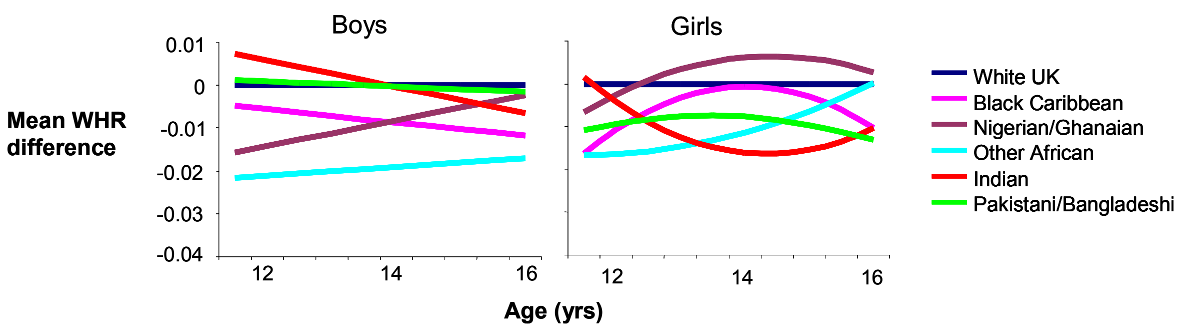
[2]WHR - Girls

Null Model: ethnicity*age, ethnicity*age^2

Baseline model: ethnicity*age, ethnicity*age^2, age*pubertal status, pubertal status*height SDS

Figure 3.28 Ethnic differences in mean WHR compared to White UK

(adjusted for pubertal status and height)



3.6.4 WHR - Key Points

- Mean WHRs were higher for boys than girls; however the overall trend was very similar for both sexes with a gradual decline until around 14yrs.

- Ethnic differences in absolute terms were extremely small because the individuals with larger hips also had larger waists.

- The effect of pubertal status and height on WHR was also extremely small.

- Therefore although there were some significant ethnic differences in WHR these have to be interpreted in light of the very small absolute differences.

- The ranking of the groups by WHR is different to that seen for BMI; for example, the Other African boys had the lowest WHR at all ages, and the Black Caribbean girls had lower WHRs than the Nigerian/Ghanaians, White UK and Other Africans at 16yrs.

3.7 Comparison of the anthropometric measures by ethnic group

A comparison of the relationship between the anthropometric measures by ethnic group was undertaken. There was a strong positive correlation between BMI SDS and waist SDS for both boys and girls, with correlation coefficients ranging from r=0.778 at 11-13yrs for Other African boys to r=0.922 for Indian boys at 14-16yrs (Table 3.20). There was generally a moderate positive correlation between height SDS and waist SDS, although in many groups the correlation was lower at 14-16yrs than 11-13yrs. At both ages, the correlation between height SDS and waist SDS was strongest for the Pakistani/Bangladeshi girls. The correlation between height SDS and BMI SDS was positive (with the exception of the White UK girls at 14-16yrs) but generally weak, particularly at 14-16yrs.

Table 3.20 Correlation between BMI SDS, Waist SDS and Height SDS by gender and ethnicity

Correlation[1] between:		White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys							
BMI SDS and Waist SDS	11-13yrs	0.841	0.822	0.810	0.778	0.816	0.835
	14-16yrs	0.896	0.890	0.823	0.864	0.922	0.892
Height SDS and Waist SDS	11-13yrs	0.416	0.437	0.402	0.405	0.467	0.368
	14-16yrs	0.310	0.309	0.364	0.423	0.291	0.321
Height SDS and BMI SDS	11-13yrs	0.348	0.315	0.254	0.366	0.325	0.272
	14-16yrs	0.205	0.157	0.129	0.276	0.175	0.183
Girls							
BMI SDS and Waist SDS	11-13yrs	0.837	0.824	0.809	0.794	0.838	0.826
	14-16yrs	0.855	0.884	0.869	0.818	0.878	0.870
Height SDS and Waist SDS	11-13yrs	0.317	0.378	0.343	0.331	0.319	0.464
	14-16yrs	0.153	0.273	0.308	0.300	0.229	0.406
Height SDS and BMI SDS	11-13yrs	0.235	0.246	0.236	0.225	0.236	0.332
	14-16yrs	-0.005	0.098	0.095	0.071	0.133	0.255

[1]r value given for each pair of body size measures

Categorical variables were derived for BMI SD and waist SD scores: <-1.5SD; -1.5SD to <0SD; >=0SD to <1.5SD; ≥1.5SD. Cross-tabulations between these categorical variables confirmed the strong correlations observed; figures are presented for 11-13yrs (boys Table 3.21; girls Table 3.22). No pupil with a BMI SD score <-1.5 had a Waist SD ≥1.5SD; similarly no pupil who had a BMI SD score ≥1.5SD had a Waist SD score <-1.5SD. In general, proportions in each of the cells of the cross-tabulation were similar for different ethnic and gender groups but there were some differences. Of those with the highest BMIs (SD ≥1.5SD), the majority in every ethnic group also had a Waist SD score ≥1.5SD; however the proportion ranged for boys from 57.7% for Nigerian/Ghanaians to 78.0% for

Indians, and for girls from 78.8% of Black Caribbeans to 90.0% of Indian girls. Therefore, for both sexes, a large waist was most commonly associated with a high BMI for the Indians. Furthermore, a high BMI was more likely to coexist with a large waist in girls than boys.

Table 3.21 Boys: Cross-tabulation of Waist SDS and BMI SDS (11-13yrs)

			Waist SDS		
BMI SDS	N (100%)	<-1.5SD (%)	-1.5-0SD (%)	0-1.5SD (%)	1.5+SD (%)
BOYS					
White UK					
<1.5	27	55.6	44.4	0	0
-1.5-0	138	15.2	69.6	15.2	0
0-1.5	209	0.5	21.5	71.8	6.2
1.5+	116	0	1.7	24.1	74.1
Black Caribbean					
<1.5	11	54.6	45.5	0	0
-1.5-0	112	14.3	68.8	16.1	0.9
0-1.5	162	1.9	29.6	64.8	3.7
1.5+	104	0	1.9	31.7	66.4
Nigerian/Ghanaian					
<1.5	4	50	50	0	0
-1.5-0	57	15.8	70.2	14.0	0
0-1.5	94	1.1	39.4	55.3	4.3
1.5+	52	0	5.8	36.5	57.7
Other African					
<1.5	15	53.3	46.7	0	0
-1.5-0	55	20	52.7	27.3	0
0-1.5	91	3.3	31.9	60.4	4.4
1.5+	48	0	8.3	22.9	68.8
Indian					
<1.5	32	43.8	50.0	6.3	0
-1.5-0	68	10.3	58.8	30.9	0
0-1.5	78	2.6	19.2	68.0	10.3
1.5+	59	0	0	22.0	78.0
Pakistani/Bangladeshi					
<1.5	23	65.2	34.8	0	0
-1.5-0	102	22.6	52.9	24.5	0
0-1.5	104	1.0	26.9	66.4	5.8
1.5+	76	0	1.3	27.6	71.1

Table 3.22 Girls: Cross-tabulation of Waist SDS and BMI SDS (11-13yrs)

		Waist SDS			
BMI SDS	N (100%)	<-1.5SD (%)	-1.5-0SD (%)	0-1.5SD (%)	1.5+SD (%)
GIRLS					
White UK					
<1.5	15	13.3	80.0	6.7	0
-1.5-0	120	10.8	55.0	33.3	0.8
0-1.5	180	1.1	13.9	67.8	17.2
1.5+	65	0	0	12.3	87.7
Black Caribbean					
<1.5	19	21.1	57.9	10.5	10.5
-1.5-0	87	9.2	58.6	31.0	1.2
0-1.5	146	2.7	17.8	69.9	9.6
1.5+	137	0	0.73	20.4	78.8
Nigerian/Ghanaian					
<1.5	8	12.5	50.0	37.5	0
-1.5-0	50	2.0	52.0	44.0	2.0
0-1.5	149	1.3	16.1	65.1	17.5
1.5+	90	0	0	12.2	87.8
Other African					
<1.5	3	66.7	33.3	0	0
-1.5-0	51	11.8	47.1	37.3	3.9
0-1.5	68	0	17.7	69.1	13.2
1.5+	55	0	0	14.6	85.5
Indian					
<1.5	16	62.5	18.8	12.5	6.3
-1.5-0	59	18.6	54.2	25.4	1.7
0-1.5	66	1.5	18.2	65.2	15.2
1.5+	40	0	0	10.0	90.0
Pakistani/Bangladeshi					
<1.5	14	64.3	35.7	0	0
-1.5-0	43	11.6	53.5	34.9	0
0-1.5	58	0	19.0	65.5	15.5
1.5+	25	0	0	12.0	88.0

3.7.1 Comparison of body measures – Key Points

- There was a strong positive correlation between BMI SDS and Waist SDS in every gender and ethnic group.
- Correlations between Height SDS and Waist SDS, and BMI SDS and Height SDS, were considerably weaker.
- The likelihood of having a large waist if BMI was high was greater for girls than boys, and greater for Indians than the other ethnic groups.

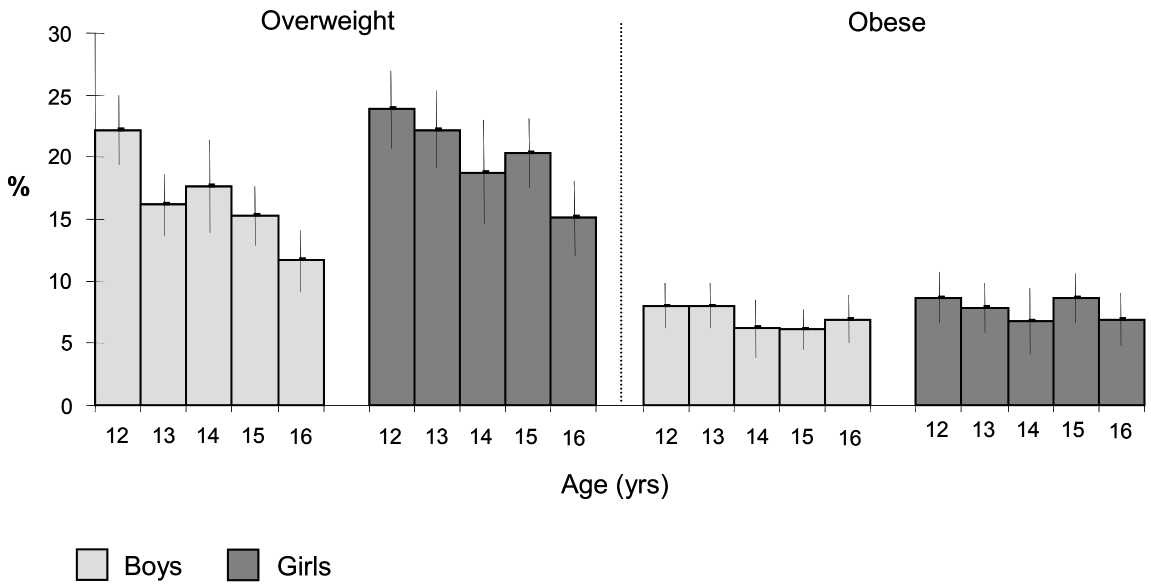
3.8 Overweight and obesity

Continuous measures of body size are the focus of this thesis, however it is of interest to examine how the age, sex and ethnic differences observed in BMI translate into differences in proportions classified as overweight and obese [using IOTF criteria, more details in the Methods (Chapter 2)].

3.8.1 Overall trends in overweight and obesity

The proportion classified as overweight generally decreased with increasing age for both boys and girls (Figure 3.29). This corresponds with the age trends in BMI SD scores described previously. The proportion classified as obese showed less variability with age. A higher proportion of girls than boys were classified as being overweight at all ages, however confidence intervals were wide and sex differences were generally not statistically significant. There was no sex difference in the proportion classified as obese.

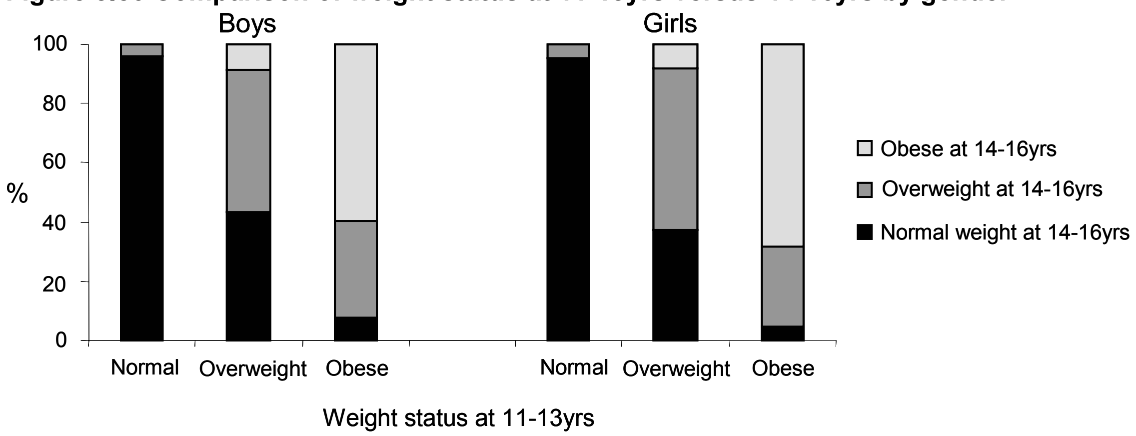
Figure 3.29 Percentage (and 95% CI) overweight and obese by age and sex



Over 95% of both boys and girls who were classified as normal weight at 11-13yrs remained in this category at 14-16yrs (Figure 3.30). A large proportion (60% of boys and 68% of girls) classified as obese at 11-13yrs were still obese at 14-16yrs. Of those who were no longer obese, the majority were classified as overweight. Only 8% of boys and 5% of girls who were obese at 11-13yrs were normal weight at 14-16yrs. Of those overweight at 11-13yrs, roughly half remained overweight (48% of boys, 54% of girls).

Of the rest, the majority were classified as normal weight by 14-16yrs. Only 8% of the overweight boys and girls became obese by 14-16yrs. Therefore, few children who were not obese in early adolescence become so by late adolescence. Indeed of the children who were obese at 14-16yrs, three quarters were already obese at 11-13yrs; the rest were overweight at 11-13yrs (apart from one boy, no child who was normal weight at 11-13yrs was obese at 14-16yrs).

Figure 3.30 Comparison of weight status at 11-13yrs versus 14-16yrs by gender



The comparison of overweight and obesity by age helps elucidate why the proportion overweight drops with increasing age but not the proportion obese does not; many overweight children become normal weight but fewer obese children change weight status.

3.8.2 Ethnic differences in overweight and obesity

There were no significant ethnic differences in the proportion of boys classified as overweight or obese at either 11-13yrs or 14-16yrs (Table 3.23). In every ethnic group, the proportion of overweight boys was slightly lower at 14-16yrs than 11-13yrs. A similar pattern was observed in all groups for obesity, with the exception of the White UK boys for whom the proportion did not decrease. None of the age differences were statistically significant.

In contrast to the boys, significant ethnic differences in both overweight and obesity were apparent at both ages in girls (Table 3.23). The Other African girls had the highest proportions of overweight and the White UK girls the lowest. Compared to the White UK, the Other Africans and Black Caribbeans had significantly more overweight at 11-13yrs and 14-16yrs, and the Nigerian/Ghanaians at 14-16yrs. Fewer girls in every ethnic group were overweight at 14-16yrs compared to 11-13yrs, however none of these age differences was statistically significant. The Black Caribbean girls were significantly more likely to be obese at both ages than the White UK girls. Obesity rates were lowest for the Indian and Pakistani/Bangladeshi girls.

Table 3.23 Ethnic differences in Overweight and Obesity at 11-13yrs and 14-16yrs

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys							
N		490	389	207	209	237	305
Overweight (%)	11-13	19.4 (15.9-22.9)	19.3 (15.3-23.2)	19.8 (14.3-25.3)	16.3 (11.2-21.3)	19.4 (14.3-24.5)	17.4 (13.1-21.7)
	14-16	13.9 (10.8-16.9)	15.2 (11.6-18.7)	16.9 (11.8-22.1)	11.5 (7.1-15.8)	15.6 (11.0-20.3)	14.8 (10.8-18.8)
Obese (%)	11-13	5.3 (3.3-7.3)	10.0 (7.0-13.0)	7.7 (4.1-11.4)	8.1 (4.4-11.9)	8.0 (4.5-11.5)	9.5 (6.2-12.8)
	14-16	5.5 (3.5-7.5)	8.7 (5.9-11.6)	4.8 (1.9-7.8)	5.3 (2.2-8.3)	5.5 (2.6-8.4)	7.2 (4.3-10.1)
Girls							
N		380	389	297	177	181	140
Overweight (%)	11-13	16.1 (12.3-19.8)	27.0 (22.6-31.4)*	22.6 (17.8-27.3)	32.2 (25.3-39.2)*	23.8 (17.5-30.0)	20.0 (13.3-26.7)
	14-16	12.1 (8.8-15.4)	20.6 (16.5-24.6)*	21.9 (17.2-26.6)*	23.2 (16.9-29.4)*	14.9 (9.7-20.2)	14.3 (8.4-20.2)
Obese (%)	11-13	6.1 (3.6-8.5)	13.9 (10.4-17.3)*	11.1 (7.5-14.7)	6.8 (3.0-10.5)	2.8 (0.4-5.2)	2.1 (0.0-4.6)
	14-16	5.3 (3.0-7.5)	11.8 (8.6-15.0)*	10.4 (6.9-13.9)	6.8 (3.0-10.5)	3.3 (0.7-5.9)	2.9 (0.06-5.7)

*significantly different from White UK group (non-overlapping confidence intervals)

4 School contexts and their association with body size

This chapter focuses on the school environments of the DASH pupils; it highlights how different the school environments often were from one another and details the association between school characteristics and body size (BMI SDS and Waist SDS). In the first part of the chapter ethnic and gender differences in the school characteristics are discussed. The second part of this chapter then focuses on whether any of the variance in the body size measures was due to differences between schools, and whether characteristics of the school environment were associated with body size. The proportion of variance at the neighbourhood level was also examined in addition to school at this stage because these contexts do not exist independently of one another. It was therefore important to check that variation in body size due to differences between neighbourhoods was not wrongly assumed to be due to differences between schools and vice versa.

The aims of this chapter were to:

1. Characterise the schools in the DASH study with a focus on ethnic and gender differences in school attended.

2. Examine how much of the variance in body size was due to differences between schools and between neighbourhoods, and whether this differed by ethnicity.

3. Determine whether any of the school characteristics were associated with body size, and whether these associations differed by ethnicity or age.

4. Determine how much of the variance in body size was explained by school characteristics.

4.1 Overview of the DASH schools

4.1.1 General school characteristics

School Type

Forty-nine schools participated in the DASH longitudinal study. The majority were non-denominational and mixed sex (n=27). Twelve schools had a religious affiliation, and 17 were single sex (Table 4.1).

Table 4.1 Distribution of DASH schools by school sex and religious affiliation

	Non-denominational	Church of England	Catholic
Mixed sex	27	2	3
All girls	4	2	3
All boys	6	0	2

Overall, 36% of the girls attended a single-sex school compared to 27% of the boys. Almost 60% of Nigerian/Ghanaian girls attended an all-girls school; a significantly higher proportion than any other group (Table 4.2). The White UK boys were the least likely to attend a single-sex school. There were significant gender differences within ethnic group: the Nigerian/Ghanaian girls had twice as high a percentage in single-sex education as Nigerian/Ghanaian boys; the White UK girls were significantly more likely to be in single sex education than White UK boys; conversely, for the Pakistani/Bangladeshis, the boys were significantly more likely than the girls to attend a single sex school. There were no gender differences for the other ethnic groups.

Overall, 65% of the girls and 86% of the boys attended a non-denominational school; 11% of the girls and 3% of the boys attended a Church of England school; and 23% of the girls and 11% of the boys attended a Catholic school. Proportions differed by gender and ethnicity (Table 4.2). A significantly higher proportion of the White UK girls were in a non-denominational school than the Black Caribbean, Nigerian/Ghanaian, and Other African girls. The Indian and Pakistani/Bangladeshi girls were the most likely to be in a non-denominational school; significantly higher than any of the other girls. The proportion attending a non-denominational school was higher for boys than girls in every ethnic group. However the overall ethnic pattern for the boys was very similar to the girls; the Nigerian/Ghanaians were the least likely to be in a non-denominational school and the Indians and Pakistani/Bangladeshis the most likely.

Spending per pupil

There was a large variation between the schools in the annual amount of money spent per pupil, ranging from £2800 to £7028, with a mean of £3820 (this data was only available at 11-13yrs). The majority of the schools (35 of the 49) spent between £3000 and £4000 per pupil; only three schools spent more than £5000. A limitation of this data is that these figures may not represent the full funds that a school has available to them, for example some may receive additional income from grants or other initiatives. There was no significant difference in mean expenditure between the all-girls, all-boys, and mixed sex schools. Compared to the White UK pupils, Indian boys and girls were more likely to be in a school with the lowest spending per head (Table 4.3). The Nigerian/Ghanaian girls were significantly less likely than the White UK girls to attend a school with low spending.

Overall effectiveness of school

In the Ofsted reports at 14-16yrs each school was given an overall rating based on a range of factors, including academic performance and progress, personal and social development, schools management and leadership, and teaching quality. Of the 49 DASH schools, 13 were considered to be 'outstanding', 17 'good', 18 'satisfactory', and 1 'inadequate'. The all-girls schools were the most likely to be classified as outstanding; 7 (70%) of them compared to 6 (18%) of the mixed schools and none of the all-boys schools. The one inadequate school was a mixed school. Consequently, the proportion of girls attending an outstanding school was much higher than boys (44% versus 17%). There were ethnic differences in the proportion of pupils attending an outstanding school (Table 4.4). The Nigerian/Ghanaian girls were the most likely of all the girls; 69% did so compared to only 5% of the Indian girls. Of the boys, the Nigerian/Ghanaian and Indian boys were the most likely (30% and 28% respectively) and the White UK (8%) and Pakistani/Bangladeshi (11%) boys the least likely.

Table 4.2 School Type by gender and ethnicity

	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys						
N	490	389	207	209	237	305
School Sex						
All boys	16.1 (12.9-19.4)	32.6 (28.0-37.3)*	26.6 (20.5-32.6)*	29.7 (23.4-35.9)*	22.4 (17.0-27.7)	40.0 (34.5-45.5)*
School Religion						
Non-denominational	90.6 (88.0-93.2)	81.7 (77.9-85.6)*	59.9 (53.2-66.6)*	81.3 (76.0-86.7)*	99.2 (98.0-100.0)*	96.4 (94.3-98.5)*
Church of England	3.5 (1.8-5.1)	3.3 (1.5-5.1)	6.3 (2.9-9.6)	2.9 (0.6-5.2)	0.4 (0.0-1.3)*	1.3 (0.03-2.6)
Catholic	5.9 (3.8-8.0)	14.9 (11.4-18.5)*	33.8 (27.3-40.3)*	15.8 (10.8-20.8)*	0.4 (0.0-1.3)*	2.3 (0.6-4.0)
Girls						
N	380	389	297	177	181	140
School Sex						
All girls	27.1 (22.6-31.6)	39.3 (34.5-44.2)*	58.6 (53.0-64.2)*	29.9 (23.1-36.8)	21.5 (15.5-27.6)	23.6 (16.5-30.7)
School Religion						
Non-denominational	78.4 (74.3-82.6)	60.7 (55.8-65.5)*	27.3 (22.2-32.4)*	62.1 (54.9-69.4)*	92.3 (88.3-96.2)*	92.9 (88.5-97.2)*
Church of England	7.4 (4.7-10.0)	16.2 (12.5-19.9)*	17.2 (12.9-21.5)*	13.0 (8.0-18.0)	1.7 (0.0-3.5)*	6.4 (2.3-10.5)
Catholic	14.2 (10.7-17.7)	23.1 (18.9-27.3)*	55.6 (49.9-61.2)*	24.9 (18.4-31.3)*	6.1 (2.6-9.6)*	0.7 (0.0-2.1)*

Table 4.3 Schools' Spending per pupil by gender and ethnicity (11-13yrs)

	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys						
N	490	389	207	209	237	305
Q1 (highest)	35.7 (31.5-40.0)	41.6 (36.7-46.6)	30.4 (24.1-36.8)	42.6 (35.8-49.3)	30.0 (24.1-35.8)	34.4 (29.1-39.8)
Q3 (lowest)	53.5 (49.0-57.9)	47.3 (42.3-52.3)	51.2 (44.3-58.1)	44.0 (37.2-50.8)	67.1 (61.1-73.1)*	62.0 (56.5-67.4)
Girls						
N	380	389	297	177	181	140
Q1 (highest)	24.7 (20.4-29.1)	32.4 (27.7-37.1)	37.4 (31.8-42.9)*	23.2 (16.9-29.4)	14.4 (9.2-19.5)*	18.6 (12.0-25.1)
Q3 (lowest)	62.9 (58.0-67.8)	58.1 (53.2-63.0)	49.8 (44.1-55.6)*	62.1 (54.9-69.4)	76.8 (70.6-83.0)*	69.3 (61.5-77.0)

*Significantly different to White UK (non-overlapping confidence intervals)

Table 4.4 Overall effectiveness of school by gender and ethnicity (14-16yrs)

	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys						
N	490	389	207	209	237	305
Outstanding	7.8 (5.4-10.1)	18.5 (14.6-22.4)*	30.0 (23.7-36.2)*	17.2 (12.1-22.4)*	28.3 (22.5-34.0)*	11.5 (7.9-15.1)
Good	46.5 (42.1-51.0)	38.0 (33.2-42.9)	32.4 (25.9-38.8)*	42.6 (35.8-49.3)	30.8 (24.9-36.7)*	27.5 (22.5-32.6)*
Satisfactory	45.1 (40.7-49.5)	41.4 (36.5-46.3)	37.7 (31.0-44.3)	35.9 (29.3-42.4)	40.5 (34.2-46.8)	60.3 (54.8-65.8)*
Inadequate	0.6 (0.0-1.3)	2.1 (0.6-3.5)	0	4.3 (1.5-7.1)*	0.4 (0.0-1.3)	0.7 (0.0-1.6)
Girls						
N	380	389	297	177	181	140
Outstanding	28.9 (24.4-33.5)	44.7 (39.8-49.7)*	69.0 (63.7-74.3)*	38.4 (31.2-45.7)	48.1 (40.7-55.4)*	33.6 (25.7-41.5)
Good	41.8 (36.9-46.8)	18.8 (14.9-22.7)*	14.5 (10.5-18.5)*	21.5 (15.4-27.6)*	18.8 (13.0-24.5)*	20.7 (13.9-27.5)*
Satisfactory	28.7 (24.1-33.3)	35.7 (30.9-40.5)	16.2 (12.0-20.4)*	37.3 (30.1-44.5)	33.1 (26.2-40.1)	45.0 (36.7-53.3)*
Inadequate	0.5 (0.0-1.3)	0.8 (0.0-1.6)	0.3 (0.0-1.0)	28.2 (0.4-5.3)	0	0.7 (0.0-2.1)

*Significantly different to White UK (non-overlapping confidence intervals)

4.1.2 Social environment of the schools

Two measures of school social environment were considered; ethnic composition and the proportion of pupils speaking English as a second language. Speaking English as a second language is likely to reflect ethnicity, generational status, and levels of acculturation.

4.1.2.1 Ethnic composition of the schools

Examination of the school census ethnicity data showed that the schools varied considerably in ethnic composition (Table 4.5). For example, the proportion of White British pupils in the schools ranged from 2.5% to 79.6% in 2003. The next largest groups were the Black Africans and Black Caribbeans. The majority of the schools were ethnically diverse, and in many schools the largest ethnic group accounted for a third of pupils or less. The White British pupils formed the largest of the ethnic groups in 15 of the schools in 2003 (12 in 2006). However at both time points only three of the DASH schools had more than 50% of their pupils being White British. No other ethnic group comprised more than 50% of a school's population. The White Other, Black Caribbean, Black African, Indian, and Pakistani groups each made up at least a third of the pupil population in at least one school.

Table 4.5 Ethnic composition of the schools in 2003 and 2006

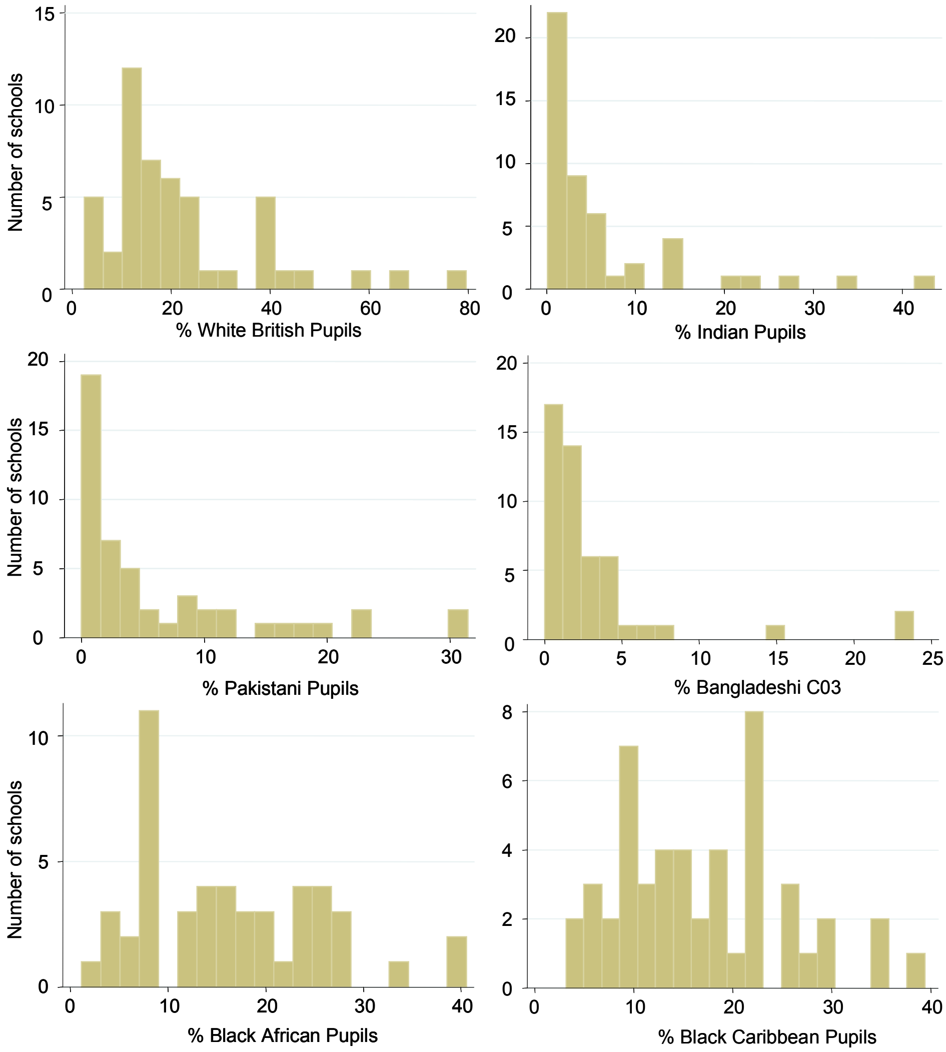
	2003[1]				2006[1]			
	Mean %	Min %	Max %	N schools where largest ethnic group*	Mean %	Min %	Max %	N schools where largest ethnic group
White UK	21.8	2.5	79.6	15	19.3	2.8	79.0	12
Irish	1.3	0	12.8	0	0.8	0	9.2	0
Irish Traveller	0.1	0	1.5	0	0.1	0	0.9	0
White Other	8.5	1.2	37.1	2	9.3	1.4	31.4	2
Black Caribbean	17.1	3.2	39.4	11	14.8	2.3	38.8	9
Black African	16.3	1.2	40.5	9	17.9	1.7	45.4	16
Black Other	2.9	0	15.3	0	3.0	0	13.0	0
Indian	6.5	0.1	43.6	5	5.6	0	31.5	3
Pakistani	6.2	0	31.4	4	6.4	0	33.5	5
Bangladeshi	3.2	0	23.9	1	3.4	0	25.5	1
Asian Other	2.9	0	12.1	0	3.6	0	10.9	0
Mixed White & Black Caribbean	2.8	0	7.0	0	3.1	0.5	7.9	0
Mixed White & Black African	0.6	0	1.9	0	0.9	0	4.0	0
Mixed White & Asian	0.7	0	2.1	0	0.7	0	2.0	0
Mixed Other	2.1	0	7.6	0	2.6	0.2	6.4	0
Roma	0.1	0	1.3	0	0.2	0	1.6	0
Chinese	0.7	0	3.7	0	0.8	0	2.9	0
Other	5.2	0	20.9	1	6.2	0.6	24.5	1
Unclassified	0.8	0	10.2	/	1.3	0	11.9	/

[1]Data from 2003 and 2006 School Census

*Totals 48 as 1 school had equal numbers of White UK and Black Caribbean pupils.

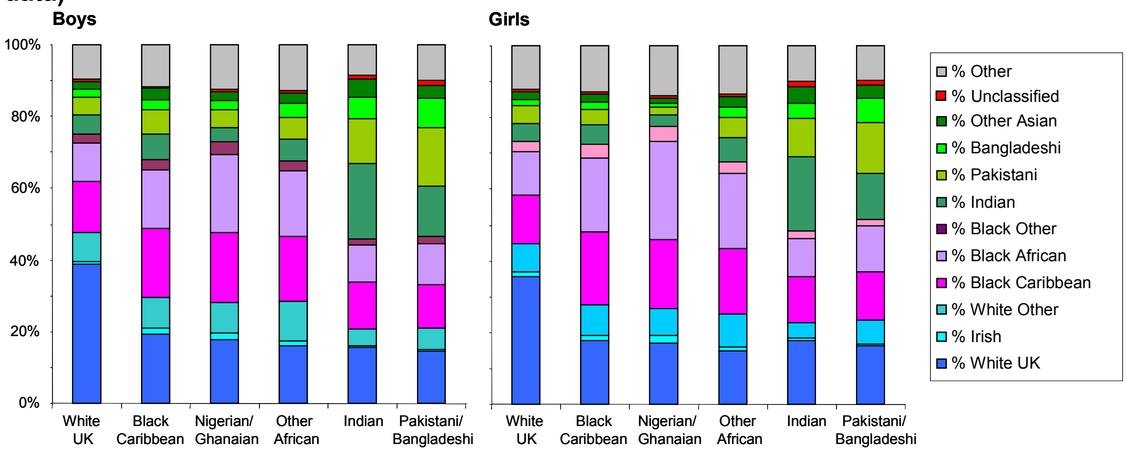
There was a fairly even spread across the schools in the proportion of Black Caribbean and Black African ethnic density (that is, some of the schools had low percentages of pupils from these groups, some medium levels, and some relatively high). In contrast, there was a relatively high degree of ethnic clustering by school for the Indian, Pakistani and Bangladeshi groups; many schools had very low proportions of pupils from these ethnic groups, and a few had relatively high proportions (Figure 4.1). The White British group comprised between 10% and 20% of their school populations in many of the schools. There were a small number of schools with very high proportions of White UK pupils, much higher than the proportions reached by any of the other ethnic groups.

Figure 4.1 Distribution of schools by proportion of each ethnic group (2003 data)



The average school ethnic composition (from the school census data) was examined by DASH pupils' ethnicity (Figure 4.2). The 'other' category in the census includes mixed ethnicities (of which mixed White and Black Caribbean was the largest), Irish travellers, Roma, Chinese, and Other. A small proportion of pupils were not classified to an ethnic group. These figures emphasise the ethnic diversity of the schools in the DASH study . Ethnic clustering was greatest for the White UK DASH pupils; on average almost 40% of the pupils in their schools were of the same ethnicity as themselves. The next biggest ethnic groups in their schools were Black African and Black Caribbean. The DASH pupils from all of the other ethnic groups attended schools where on average less than 20% of the pupils were White UK. The school ethnic distributions for the Black Caribbean, Nigerian/Ghanaian, and Other African pupils were broadly similar. Both the Indian and Pakistani/Bangladeshi DASH pupils attended schools where on average over a third of the pupils were South Asian (Indian, Pakistani or Bangladeshi). Of the boys' ethnic minority groups, ethnic clustering in the schools was greatest for the Indians; on average they attended a school where 21% of the pupils were the same ethnicity as themselves. For girls, it was the Nigerians/Ghanaians who had the highest level; 27% of their fellow pupils were Black African on average (although as there was no further breakdown it is not possible to know what proportion of these African pupils were Nigerian or Ghanaian).

Figure 4.2 Ethnic density of schools by gender and ethnicity of the DASH pupils (2003 census data)



Ethnic-specific quartiles of each of the ethnic density variables were calculated. The mean density in each quartile differed by ethnic density variable (Table 4.6). In particular, the mean density in the highest density quartile (Q4) was considerably higher for White UK density than the other groups. The mean density in Q1 was slightly lower for the Indians and Pakistani/Bangladeshis than the other groups.

Table 4.6 Summary of school ethnic specific ethnic density quartiles

Ethnic density Quartiles[1]		Boys		Girls	
		Mean (%)	Range (%)	Mean (%)	Range (%)
White UK	Q 1 (low)	11.2	2.5-17.3	10.4	2.5-14.6
	Q 2	24.8	17.7-37.3	21.9	14.9-32.8
	Q 3	40.8	39.0-46.2	40.2	34.7-48.7
	Q 4 (high)	63.4	48.7-79.6	67.4	50.9-79.6
Black Caribbean	Q 1 (low)	8.0	2.3-10.4	10.3	2.3-13.0
	Q 2	13.2	10.5-15.7	15.6	13.2-18.3
	Q 3	20.6	16.9-23.0	21.6	18.5-24.7
	Q 4 (high)	28.8	24.7-39.4	31.2	25.2-38.8
Nigerian/Ghanaian	Q 1 (low)	8.8	2.2-14.7	14.3	3.7-23.7
	Q 2	19.8	15.1-23.9	26.0	23.9-27.5
	Q 3	26.3	24.0-32.5	35.5	27.6-39.9
	Q 4 (high)	39.4	33.1-45.4	43.7	40.5-45.4
Other African	Q 1 (low)	9.1	1.2-12.4	10.5	3.7-14.7
	Q 2	16.0	12.5-18.5	18.1	15.1-19.9
	Q 3	20.6	18.7-23.9	24.2	20.1-27.5
	Q 4 (high)	30.4	24.2-45.4	37.7	27.6-45.4
Indian	Q 1 (low)	5.3	0.3-9.7	3.7	0.12-5.8
	Q 2	14.9	10.9-17.7	13.0	5.9-17.7
	Q 3	24.2	20.1-27.3	23.9	20.1-27.3
	Q 4 (high)	36.4	31.5-43.6	37.0	31.5-43.6
Pakistani/Bangladeshi	Q 1 (low)	5.7	0.8-10.4	5.0	1.1-8.5
	Q 2	22.4	12.1-26.6	13.0	9.2-26.5
	Q 3	33.8	27.3-37.8	28.7	27.3-29.8
	Q 4 (high)	42.7	39.9-45.7	39.2	32.8-45.7

[1]School Census data

4.1.2.2 English as a second language

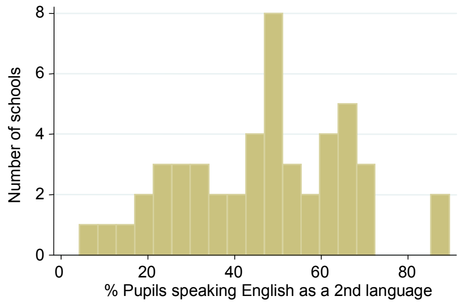
The proportion of pupils who spoke English as a second language also showed large variability between the schools, ranging from less than 5% to almost 90% at both time points (Table 4.7; Figure 4.3).

Table 4.7 Percentage of pupils speaking English as 2nd language

	Mean	Min	Max
2003	44.3	3.5	87.5
2006	46.6	4.2	89.5

(school census data)

Figure 4.3 Distribution of schools by % of pupils speaking English as a 2nd language (census 2006)



The White UK pupils attended schools where the lowest proportion of pupils spoke English as a second language; at 14-16yrs 57% of the White UK boys were in a school with the lowest proportion speaking English as a second language (Q1) compared to 7% of Other African boys and 10% of Pakistani/Bangladeshi boys (Table 4.8). The Indian and Pakistani/Bangladeshi boys and girls were the most likely to attend a school with a high proportion speaking English as a second language. There were gender differences; the White UK boys were significantly more likely to be in Q1 than the White UK girls (57% versus 39%). In contrast the Nigerian/Ghanaian girls (34%) were significantly more likely than the Nigerian/Ghanaian boys (10%) to attend a school in Q1.

Table 4.8 Proportion of pupils in the schools speaking English as a second language by gender and ethnicity (census data)

	Age	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys							
N		490	389	207	209	237	305
Q1 (lowest)	11-13yrs	47.1 (42.7-51.6)	25.2 (20.9-29.5)*	15.9 (10.9-21.0)*	12.0 (7.5-16.4)*	15.2 (10.6-19.8)*	6.9 (4.0-9.7)*
	14-16yrs	57.3 (52.9-61.7)	18.0 (14.2-21.8)*	10.1 (6.0-14.3)*	7.2 (3.6-10.7)*	20.7 (15.5-25.9)*	9.8 (6.5-13.2)*
Q4 (highest)	11-13yrs	10.8 (8.1-13.6)	23.1 (18.9-27.3)*	17.9 (12.6-23.1)	35.4 (28.9-41.9)*	49.4 (43.0-55.8)*	47.2 (41.6-52.8)*
	14-16yrs	8.5 (6.1-11.1)	18.8 (14.9-22.7)*	11.1 (6.8-15.4)	27.8 (21.6-33.9)*	54.4 (48.0-60.8)*	43.9 (38.3-49.5)*
Girls							
N		380	389	297	177	181	140
Q1 (lowest)	11-13yrs	52.9 (47.9-57.9)	31.9 (27.2-36.5)*	35.7 (30.2-41.2)*	17.5 (11.9-23.2)*	26.0 (19.5-32.4)*	15.0 (9.0-21.0)*
	14-16yrs	38.7 (33.8-43.6)^	23.7 (19.4-27.9)*	34.0 (28.6-39.4)	14.7 (9.4-20.0)*	15.5 (10.2-20.8)*	7.1 (2.8-11.5)*
Q4 (highest)	11-13yrs	12.4 (9.0-15.7)	21.6 (17.5-25.7)*	8.4 (5.2-11.6)	33.3 (26.3-40.3)*	45.9 (38.5-53.2)*	57.9 (49.6-66.1)*
	14-16yrs	12.4 (9.0-15.7)	19.3 (15.3-23.2)	6.1 (3.3-8.8)*	36.2 (29.0-43.3)*	57.5 (50.2-64.7)*	57.9 (49.6-66.1)*

*Significantly different to White UK (non-overlapping confidence intervals)

4.1.3 *Socio-economic status of the schools*

Ethnic, gender, and age differences in three proxy measures of school socio-economic status (SES) were examined; proportion of pupils receiving free school meals, academic achievement, and absenteeism.

4.1.3.1 Free school meals

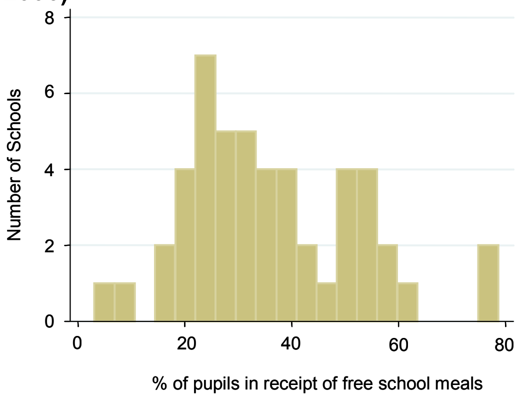
Sizeable proportions of the pupils in many of the schools received free school meals (Figure 4.4). Two schools had considerably higher rates than the others. There was large variation between the schools, with a more than 25 fold difference between the school with the lowest proportion and the school with the highest. Proportions were broadly similar at both time points (Table 4.9).

Table 4.9 Percentage of pupils receiving free school meals

	Mean	Min	Max
2003	37.1	5.6	75.4
2006	36.1	3.1	78.7

(school census data)

Figure 4.4 Distribution of schools by % of pupils receiving free school meals (census 2006)



The proportion of pupils receiving free school meals in the schools attended varied by ethnicity and gender. For boys, the White UK and Indians were the most likely to attend a school with the lowest proportion of pupils receiving free meals (Q1). The Other Africans were the most likely to attend a school with the highest proportions (Q4); over 40% did so compared to less than 20% of the Indian and White UK boys. In contrast, for the girls it was the Nigerian/Ghanaian, Indian, and Black Caribbean girls who were most likely to attend a school with the lowest proportions (Q1), and the Other Africans and Pakistani/Bangladeshis who were the most likely to attend a school in Q4. With the exception of the Indians and

Pakistani/Bangladeshis, the girls were significantly more likely to attend a school with the lowest proportion receiving free school meals than the boys.

4.1.3.2 Absenteeism

Schools classify absenteeism as either authorised or unauthorised. Substantially more half days were lost through authorised absence than unauthorised absence (Table 4.10). Absence rates were slightly higher on average in 2003 than 2006.

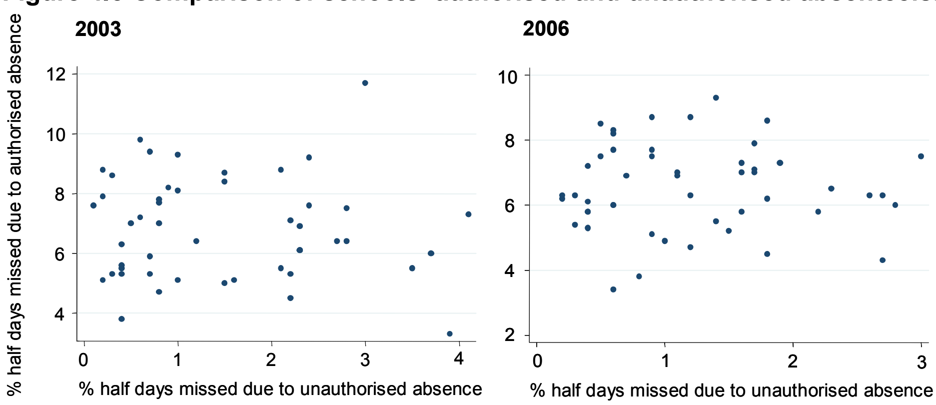
Table 4.10 Authorised and Unauthorised Absence Rates

		Mean	Min	Max
Unauthorised* (%)				
	2003	1.49	0.1	4.1
	2006	1.21	0.2	3.0
Authorised* (%)				
	2003	6.8	3.3	11.7
	2006	6.5	3.4	9.3

* percentage of half days missed

There was little correlation between unauthorised and authorised absence rates within a school (Figure 4.5). The distribution of the authorised absence rates by school approached normality, however the distribution of the schools by unauthorised absence rates was positively skewed; more schools reported lower rates than higher ones.

Figure 4.5 Comparison of schools' authorised and unauthorised absenteeism rates



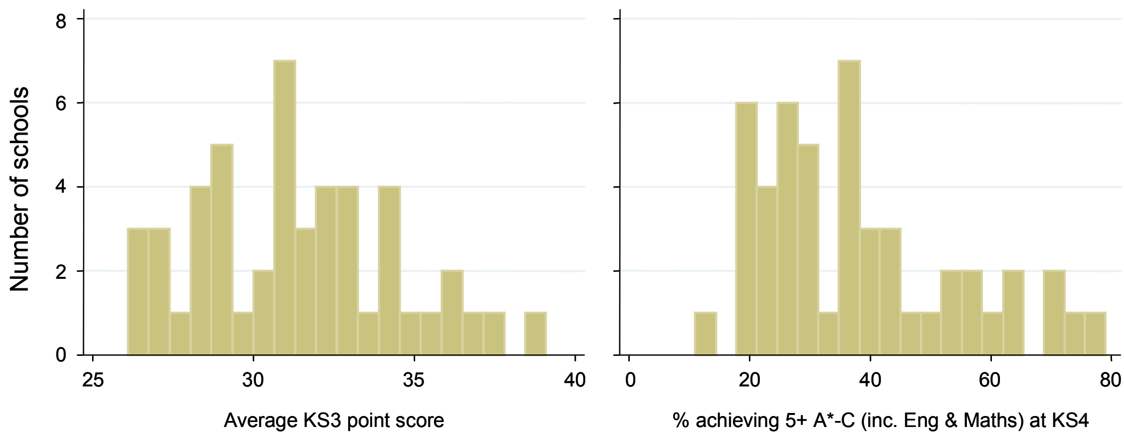
Only 12% of the Indian boys attended a school with high unauthorised absence (Q4) compared to over 30% of the Pakistani/Bangladeshi boys and over 25% of the Other African boys (Table

4.13). For girls, the Nigerian/Ghanaians and Indians were significantly more likely to attend a school with low unauthorised absence compared to White UK girls (Table 4.14). Similar to the boys, the Pakistani/Bangladeshi girls were the most likely to attend a school with high unauthorised absence (over a third in Q4). Girls in every ethnic group were more likely than the boys to attend a school with low unauthorised absence, with the exception of the Pakistani/Bangladeshis.

4.1.3.3 Academic achievement

Some of the schools achieved much higher levels of academic performance than others. At Key Stage 3 (KS3), the average point score was 31.4 (range from 26.1 – 39.1); a higher score reflects a higher level of average attainment by the pupils. By KS4 (GCSE) striking differences in the levels of academic performance had emerged. The mean proportion of pupils achieving 5 or more A*-C grades including English and Maths was 37.9%, with a wide range of 11 to 79%. There tended to be more schools doing less well academically, and fewer with higher academic levels (Figure 4.6).

Figure 4.6 Distribution of schools by academic performance at KS3 and KS4



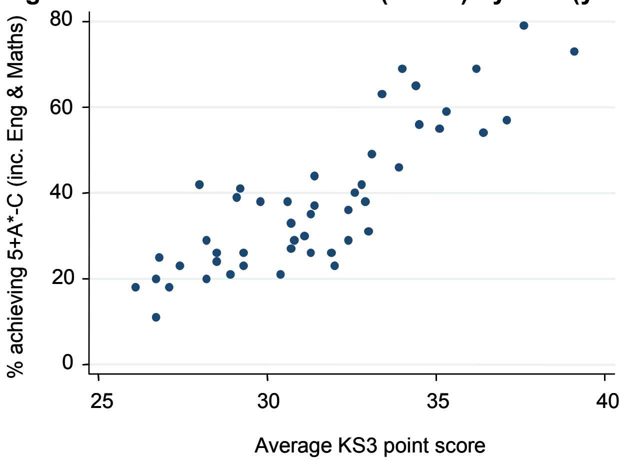
Quartiles of the academic performance scores at KS3 and GCSE level were compared. Most schools performed at a similar level at both time points relative to the other DASH schools (Table 4.11). For example, of the 12 schools in the highest academic performance quartile at KS3, 11 were still in the top quartile at the GCSE stage. A scatter plot of the continuous scores at both KS3 and KS4 confirms the close relationship (Figure 4.7). On average, KS3 and GCSE results were significantly better in all-girls schools than mixed and all-boys schools. There was no significant difference between the mixed and the all-boys schools in mean score on either measure. As a result, the girls on average attended schools with higher academic levels than the boys.

Table 4.11 Distribution of schools by quartiles of GCSE and KS3 performance

		KS4 (GCSE)[1]			
		Q1 (high performance)	Q2	Q3	Q4 (low performance)
KS3	Q1 (high performance)	11	1	0	0
	Q2	1	6	2	2
	Q3	0	3	6	4
	Q4 (low performance)	0	2	1	10

[1]Table shows number of schools in each quartile of performance

Figure 4.7 Schools' mean KS3 (x axis) by KS4 (y axis) scores



There were ethnic differences in the academic performance of school attended and these differed by gender. Almost 70% of the Nigerian/Ghanaian girls attended a school with the highest academic performance (Q1) at both 11-13yrs and 14-16yrs. In contrast, less than 30% of the Pakistani/Bangladeshi girls did so. The Other African and Black Caribbean girls were the most likely to attend a school with the lowest academic performance (Q4), and the Indian girls least likely. Compared to the girls, the proportion of boys who attended a school in Q1 was low in every ethnic group, ranging from 3% of Pakistani/Bangladeshis at 11-13yrs to 20% of Indians at 14-16yrs. The Black Caribbean, Nigerian/Ghanaian, and Other African boys were the most likely to attend a school in Q4 at both ages. There was therefore a stark gender difference for the Nigerian/Ghanaian pupils in the educational attainment of the schools they attended.

4.1.3.4 Special Educational Needs

Related to a school's academic performance is the proportion of their pupils who have special educational needs (SEN). There were large differences between the schools in the proportion of their pupils who had SEN, either with or without statements (Table 4.12). As would be expected, there were many more pupils without statements than with. In some schools, more than half of the pupils had SEN without statements. The all-girls schools had significantly lower proportions of pupils classified as having SEN (either with statement or without statement) than the all-boys and mixed schools.

Table 4.12 Percentage of Pupils in the DASH schools with Special Educational Needs

	Mean	Min	Max
With statements (%)			
2003	2.65	0.6	5.9
2006	2.50	0.7	5.3
Without statements (%)			
2003	21.8	4.3	50.1
2006	26.4	6.7	67.8

The Indian boys were the most likely to attend a school with the lowest proportion of pupils with SEN with statement (Q1) and the Pakistani/Bangladeshi girls least likely (Table 4.13 and Table 4.14). However some schools changed quartile between Waves of the study and consequently there were often large differences by age (for example 24% of the Pakistani/Bangladeshi boys were in Q4 at 11-13yrs compared to 7% at 14-16yrs).

Table 4.13 Boys: School SES by ethnicity

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N		490	389	207	209	237	305
Unauthorised absence							
Q1 (lowest)	11-13	16.7 (13.4-20.1)	26.7 (22.3-31.2)*	18.8 (13.5-24.2)	16.3 (11.2-21.3)	47.3 (40.9-53.7)*	20.7 (16.1-25.2)
	14-16	24.3 (20.5-28.1)	31.4 (26.7-36.0)	34.3 (27.8-40.8)^	29.7 (23.4-35.9)^	43.9 (37.5-50.2)*	23.3 (18.5-28.0)
Q4 (highest)	11-13	18.6 (15.1-22.0)	21.3 (17.2-25.4)	15.0 (10.1-19.9)	28.2 (22.1-34.4)*	11.8 (7.7-16.0)	31.5 (26.2-36.7)*
	14-16	17.3 (14.0-20.7)	21.9 (17.7-26.0)	17.4 (12.2-22.6)	25.8 (19.9-31.8)	11.8 (7.7-16.0)	36.1 (30.6-41.5)*
Free School Meals							
Q1 (lowest)	11-13	32.9 (28.7-37.0)	23.4 (19.2-27.6)*	13.5 (8.8-18.2)*	13.9 (9.2-18.6)*	39.2 (33.0-45.5)	24.3 (19.4-29.1)
	14-16	43.5 (39.1-47.9)^	14.9 (11.4-18.5)^*	9.2 (5.2-13.1)*	7.7 (4.0-11.3)*	34.2 (28.1-40.3)	8.9 (5.6-12.1)^*
Q4 (highest)	11-13	19.0 (15.5-22.5)	28.0 (23.5-32.5)*	28.5 (22.3-34.7)	42.1 (35.4-48.9)*	17.3 (12.4-22.2)	25.2 (20.3-30.1)
	14-16	19.2 (15.7-22.7)	31.6 (27.0-36.3)	32.4 (25.9-38.8)*	44.5 (37.7-51.3)*	19.0 (14.0-24.0)	26.2 (21.3-31.2)
Academic Performance							
Q1 (highest)	11-13	13.3 (10.3-16.3)	7.2 (4.6-9.8)	13.5 (8.8-18.2)	5.7 (2.6-8.9)*	19.8 (14.7-24.9)	3.3 (1.3-5.3)*
	14-16	19.6 (16.1-23.1)	8.7 (5.9-11.6)	14.5 (9.7-19.3)	6.7 (3.3-10.1)*	20.3 (15.1-25.4)	4.3 (2.0-6.5)*
Q4 (lowest)	11-13	28.8 (24.8-32.8)	44.2 (39.3-49.2)*	47.8 (41.0-54.7)*	52.6 (45.8-59.5)*	16.5 (11.7-21.2)*	24.9 (20.0-29.8)
	14-16	15.9 (12.7-19.2)^	36.8 (31.9-41.6)*	32.4 (25.9-38.8)^*	49.3 (42.4-56.1)*	8.9 (5.2-12.5)*	19.7 (15.2-24.2)
Special Educational Needs (with statement)							
Q1 (lowest)	11-13	24.9 (21.1-28.7)	32.9 (28.2-37.6)	21.7 (16.1-27.4)	26.3 (20.3-32.3)	36.3 (30.1-42.5)*	19.0 (14.6-23.4)
	14-16	29.2 (25.1-33.2)	35.2 (30.5-40.0)	27.5 (21.4-33.7)	28.2 (22.1-34.4)	38.0 (31.8-44.2)	34.8 (29.4-40.1)^
Q4 (highest)	11-13	30.2 (26.1-34.3)	27.5 (23.0-32.0)	22.7 (17.0-28.5)	29.7 (23.4-35.9)	32.9 (26.9-38.9)	24.3 (19.4-29.1)
	14-16	30.8 (26.7-34.9)	17.7 (13.9-21.6)^*	25.6 (19.6-31.6)	15.8 (10.8-20.8)^*	17.3 (12.4-22.2)^*	6.9 (4.0-9.7)^*

*Significantly different to White UK (non-overlapping confidence intervals)

^significantly different from 11-13yrs within ethnic groups (non-overlapping confidence intervals)

Table 4.14 Girls: School SES by ethnicity

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N		380	389	297	177	181	140
Unauthorised absence							
Q1 (lowest)	11-13	27.6 (23.1-32.1)	44.0 (39.0-48.9)*	63.6 (58.1-69.1)*	32.2 (25.3-39.2)	50.8 (43.5-58.2)*	22.9 (15.8-29.9)
	14-16	34.2 (29.4-39.0)	45.5 (40.5-50.5)*	67.3 (62.0-72.7)*	40.1 (32.8-47.4)	49.2 (41.8-56.5)*	31.4 (23.6-39.2)
Q4 (highest)	11-13	16.3 (12.6-20.0)	23.9 (19.7-28.2)	8.4 (5.2-11.6)*	35.6 (28.5-42.7)*	14.9 (9.7-20.2)	34.3 (26.3-42.2)*
	14-16	15.0 (11.4-18.6)	17.5 (13.7-21.3)	6.7 (3.9-9.6)*	24.9 (18.4-31.3)	14.4 (9.2-19.5)	37.9 (29.7-46.0)*
Free School Meals							
Q1 (lowest)	11-13	46.1 (41.0-51.1)	27.5 (23.0-32.0)*	45.8 (40.1-51.5)	23.2 (16.9-29.4)*	46.4 (39.1-53.7)	17.1 (10.8-23.5)*
	14-16	57.6 (52.6-62.6)	36.5 (31.7-41.3)*	56.6 (50.9-62.2)	25.4 (18.9-31.9)*	45.3 (38.0-52.6)	18.6 (12.0-25.1)*
Q4 (highest)	11-13	10.8 (7.7-13.9)	16.7 (13.0-20.4)	11.1 (7.5-14.7)	22.6 (16.4-28.8)*	16.0 (10.6-21.4)	20.7 (13.9-27.5)
	14-16	11.8 (8.6-15.1)	18.8 (14.9-22.7)	11.1 (7.5-14.7)	26.0 (19.5-32.5)*	14.9 (9.7-20.2)	28.6 (21.0-36.1)*
Academic Performance							
Q1 (highest)	11-13	37.4 (32.5-42.3)	40.4 (35.5-45.3)	67.7 (62.3-73.0)*	35.6 (28.5-42.7)	42.5 (35.3-49.8)	28.6 (21.0-36.1)
	14-16	41.1 (36.1-46.0)	37.5 (32.7-42.4)	67.7 (62.3-73.0)*	33.3 (26.3-40.3)	42.5 (35.3-49.8)	25.7 (18.4-33.0)*
Q4 (lowest)	11-13	15.3 (11.6-18.9)	28.8 (24.3-33.3)*	13.5 (9.6-17.4)	34.5 (27.4-41.5)*	4.4 (1.4-7.4)	25.0 (17.7-32.3)
	14-16	10.8 (7.7-13.9)	23.9 (19.7-28.2)*	10.1 (6.7-13.5)	31.1 (24.2-38.0)*	6.6 (3.0-10.3)	35.0 (27.0-43.0)*
Special Educational Needs (with statement)							
Q1 (lowest)	11-13	22.1 (17.9-26.3)	21.6 (17.5-25.7)	24.6 (19.7-29.5)	22.0 (15.9-28.2)	16.6 (11.1-22.0)	10.0 (5.0-15.0)
	14-16	30.0 (25.4-34.6)	30.6 (26.0-35.2)^	47.8 (42.1-53.5)^	24.9 (18.4-31.3)	15.5 (10.2-20.8)	10.0 (5.0-15.0)
Q4 (highest)	11-13	25.3 (20.9-29.7)	16.5 (12.8-20.2)	22.6 (17.8-27.3)	22.6 (16.4-28.8)	38.7 (31.5-45.8)	27.9 (20.3-35.4)
	14-16	38.4 (33.5-43.3)^	17.0 (13.2-20.7)	22.9 (18.1-27.7)	16.9 (11.4-22.5)	29.3 (22.6-36.0)	20.7 (13.9-27.5)

*Significantly different to White UK (non-overlapping confidence intervals)

^significantly different from 11-13yrs within ethnic groups (non-overlapping confidence intervals)

4.1.4 School Ethos

Measures of school ethos were available at 14-16yrs only. Across the range of ethos measures, most schools were performing ‘above average’ or better (Table 4.15). In the overall measure of personal development and well-being five of the schools were reported to be ‘broadly average to below average’, 23 to be ‘generally above average’ and 21 to be ‘exceptionally and consistently high’. The measure that schools tended to be scored lower on was how well pupils with learning difficulties made progress; 17 were scored as ‘average to below average’ and one was considered to be ‘exceptionally low’. The ethnic and gender distribution of pupils by school ethos is presented for all ethos measures in Table 4.16 (boys) and Table 4.17 (girls).

Table 4.15 Summary of ethos measures

(numbers are no. of schools in each category), 14-16yrs only

	Exceptionally high	Above average	Average to below average	Exceptionally low
Overall personal development and well-being	21	23	5	0
How well pupils enjoy their education	22	21	6	0
Behaviour of pupils	16	25	8	0
Spiritual, moral, social & cultural development	19	21	9	0
Pupils adopt healthy lifestyles	10	30	9	0
Progress of those with learning difficulties	13	18	17	1
How well pupils are cared for, guided, supported	17	27	5	0

The all-girls schools performed the best across the range of ethos measures. For the overall measure of personal development and well-being, seven out of the 10 all-girls schools were classified as exceptional compared to only 25% of the all-boys schools and 39% of the mixed schools. All of the all-girls schools were classified as exceptional or above average. Consequently, on average the girls were more likely than the boys to be attending a school which was rated as exceptionally high in terms of overall personal development and well-being. Almost three quarters of the Nigerian/Ghanaian girls were attending such a school compared to only 28% of the White UK boys. The majority (70%) of the all-girls schools were rated as exceptionally high in terms of pupils’ enjoyment compared to 42% of the mixed schools and just 25% of the all-boys schools.

Furthermore, 70% of the all-girls schools rated exceptionally high for guidance and support, compared to 27% of the mixed schools and 25% of the all-boys schools. This pattern of the all-girls schools performing the best and the all-boys schools the worst was repeated for the other ethos measures.

For girls, the Nigerian/Ghanaians were significantly more likely than their White UK counterparts to be attending a school rated as exceptionally high for each of the ethos measures. Indian girls also tended to be in schools which performed well. The Indian, Pakistani/Bangladeshi and Nigerian/Ghanaian girls were the most likely to attend a school rated highly for pupil enjoyment. In contrast, the White UK girls generally had the lowest proportion in the best schools for each ethos measure (an exception being for healthy lifestyles for which the Other African girls had a slightly lower percentage).

For boys, the Indians and Pakistani/Bangladeshis tended to be the most likely to attend a school which rated highly for ethos. As with the girls, the White UK boys tended to be the least likely to attend such schools for most measures, and the Other African boys also had relatively low proportions, particularly for healthy lifestyles and pupils' enjoyment of learning. Only 19% of the White UK boys attended a school in the top category for guidance and support compared to 57% of Indian boys, and 69% of Indian girls.

Table 4.16 Boys: School Ethos by ethnicity (14-16yrs)

	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N	490	389	207	209	237	305
Overall Personal Development						
Exceptionally & consistently high	28.0 (24.0-31.9)	39.1 (34.2-43.9)*	44.4 (37.6-51.3)*	34.9 (28.4-41.4)	55.7 (49.3-62.1)*	63.3 (57.8-68.7)*
Generally above average	51.4 (47.0-55.9)	49.1 (44.1-54.1)	50.2 (43.4-57.1)	58.4 (51.6-65.1)	40.1 (33.8-46.4)*	32.8 (27.5-38.1)*
Average/below average	20.6 (17.0-24.2)	11.8 (8.6-15.0)*	5.3 (2.2-8.4)*	6.7 (3.3-10.1)*	4.2 (1.6-6.8)*	3.9 (1.7-6.1)*
Spiritual, Moral, Social & Cultural Development						
Exceptionally & consistently high	22.7 (18.9-26.4)	34.2 (29.5-38.9)	37.7 (31.0-44.3)	26.3 (20.3-32.3)	59.5 (53.2-65.8)	58.7 (53.1-64.2)
Generally above average	50.2 (45.8-54.6)	45.5 (40.5-50.5)	47.8 (41.0-54.7)	53.6 (46.8-60.4)	30.4 (24.5-36.3)	23.6 (18.8-28.4)
Average/below average	27.1 (23.2-31.1)	20.3 (16.3-24.3)	14.5 (9.7-19.3)	20.1 (14.6-25.6)	10.1 (6.3-14.0)	17.7 (13.4-22.0)
Pupils' enjoyment of learning						
Exceptionally & consistently high	37.3 (33.0-41.6)	42.4 (37.5-47.3)	44.0 (37.1-50.8)	35.9 (29.3-42.4)	67.5 (61.5-73.5)*	66.2 (60.9-71.6)*
Generally above average	35.9 (31.7-40.2)	44.7 (39.8-49.7)	50.2 (43.4-57.1)*	57.4 (50.7-64.2)*	28.3 (22.5-34.0)	29.8 (24.7-35.0)
Average/below average	26.7 (22.8-30.7)	12.9 (9.5-16.2)*	5.8 (2.6-9.0)*	6.7 (3.3-10.1)*	4.2 (1.6-6.8)*	3.9 (1.7-6.1)*
Pupils' behaviour						
Exceptionally & consistently high	23.9 (20.1-27.7)	28.0 (23.5-32.5)	34.8 (28.2-41.3)*	28.7 (22.5-34.9)	32.9 (26.9-38.9)	43.6 (38.0-49.2)*
Generally above average	50.0 (45.6-54.4)	54.0 (49.0-59.0)	56.0 (49.2-62.9)	51.7 (44.8-58.5)	60.8 (54.5-67.0)*	49.2 (43.5-54.8)
Average/below average	26.1 (22.2-30.0)	18.0 (14.2-21.8)*	9.2 (5.2-13.1)*	19.6 (14.2-25.0)	6.3 (3.2-9.5)*	7.2 (4.3-10.1)*
Pupils adopt healthy lifestyles						
Exceptionally & consistently high	11.2 (8.4-14.0)	12.1 (8.8-15.3)	7.2 (3.7-10.8)	7.2 (3.6-10.7)	35.4 (29.3-41.6)*	28.9 (23.7-34.0)*
Generally above average	66.1 (61.9-70.3)	73.0 (68.6-77.4)	69.6 (63.2-75.9)	77.0 (71.3-82.8)*	62.9 (56.7-69.1)	67.2 (61.9-72.5)
Average/below average	22.7 (18.9-26.4)	14.9 (11.4-18.5)*	23.2 (17.4-29.0)	15.8 (10.8-20.8)	1.69 (0.0-3.3)*	3.9 (1.7-6.1)*
Guidance and support						
Exceptionally & consistently high	19.4 (15.9-22.9)	31.1 (26.5-35.7)*	28.0 (21.9-34.2)	27.8 (21.6-33.9)	57.4 (51.0-63.7)*	20.7 (16.1-25.2)
Generally above average	73.1 (69.1-77.0)	57.8 (52.9-62.8)*	56.5 (49.7-63.3)*	59.8 (53.1-66.5)*	39.2 (33.0-45.5)*	74.8 (69.9-79.7)
Average/below average	7.6 (5.2-9.9)	11.1 (7.9-14.2)	15.5 (10.5-20.4)*	12.4 (7.9-17.0)	3.4 (1.1-5.7)	4.6 (2.2-7.0)
Progress of those with learning difficulties						
Exceptionally & consistently high	13.9 (10.8-16.9)	19.5 (15.6-23.5)	27.1 (21.0-33.2)*	22.0 (16.3-27.7)	17.7 (12.8-22.6)	22.6 (17.9-27.3)*
Generally above average	50.0 (45.6-54.4)	45.8 (40.8-50.7)	45.4 (38.6-52.2)	46.4 (39.6-53.2)	51.1 (44.6-57.5)	47.2 (41.6-52.8)
Average/below average	35.5 (31.3-39.8)	32.6 (28.0-37.3)	27.5 (21.4-33.7)	27.3 (21.2-33.4)	30.8 (24.9-36.7)	29.5 (24.4-34.7)
Exceptionally low	0.6 (0.0-1.3)	2.1 (0.6-3.5)	0	4.3 (1.5-7.1)	0.4 (0.0-1.3)	0.7 (0.0-1.6)

*Significantly different to White UK (non-overlapping confidence intervals)

Table 4.17 Girls: School Ethos by ethnicity (14-16yrs)

	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N	380	389	297	177	181	140
Overall Personal Development						
Exceptionally & consistently high	39.7 (34.8-44.7)	54.8 (49.8-59.7)*	73.7 (68.7-78.8)*	53.1 (45.7-60.5)*	64.6 (57.6-71.7)*	65.7 (57.8-73.7)*
Generally above average	47.6 (42.6-52.7)	37.3 (32.4-42.1)*	21.5 (16.8-26.3)*	37.9 (30.6-45.1)	32.6 (25.7-39.5)*	30.7 (23.0-38.5)*
Average/below average	12.6 (9.3-16.0)	8.0 (5.3-10.7)	4.7 (2.3-7.1)*	9.0 (4.8-13.3)	2.8 (0.4-5.2)*	3.6 (0.5-6.7)*
Spiritual, Moral, Social & Cultural Development						
Exceptionally & consistently high	36.1 (31.2-40.9)	53.5 (48.5-58.4)*	73.7 (68.7-78.8)*	45.8 (38.4-53.2)	68.0 (61.1-74.8)*	48.6 (40.2-57.0)
Generally above average	46.3 (41.3-51.4)	30.6 (26.0-35.2)*	19.9 (15.3-24.4)*	31.6 (24.7-38.6)*	19.9 (14.0-25.8)*	15.7 (9.6-21.8)*
Average/below average	17.6 (13.8-21.5)	15.9 (12.3-19.6)	6.4 (3.6-9.2)*	22.6 (16.4-28.8)	12.2 (7.3-17.0)	35.7 (27.7-43.7)*
Pupils' enjoyment of learning						
Exceptionally & consistently high	47.4 (42.3-52.4)	54.5 (49.5-59.5)	73.4 (68.3-78.5)*	54.2 (46.8-61.6)	72.4 (65.8-79.0)*	70.0 (62.3-77.7)*
Generally above average	33.4 (28.7-38.2)	36.8 (31.9-41.6)	21.9 (17.2-26.6)*	36.7 (29.6-43.9)	24.9 (18.5-31.2)	25.7 (18.4-33.0)
Average/below average	19.2 (15.2-23.2)	8.7 (5.9-11.6)*	4.7 (2.3-7.1)*	9.0 (4.8-13.3)*	2.8 (0.4-5.2)*	4.3 (0.9-7.7)*
Pupils' behaviour						
Exceptionally & consistently high	33.7 (28.9-38.5)	40.4 (35.5-45.3)	60.6 (55.0-66.2)*	44.6 (37.2-52.0)	40.3 (33.1-47.5)	55.7 (47.4-64.0)
Generally above average	52.4 (47.3-57.4)	43.7 (38.8-48.7)	34.0 (28.6-39.4)*	39.0 (31.7-46.2)	56.4 (49.1-63.6)	37.1 (29.0-45.2)
Average/below average	13.9 (10.4-17.4)	15.9 (12.3-19.6)	5.4 (2.8-8.0)*	16.4 (10.9-21.9)	3.3 (0.7-5.9)	7.1 (2.8-11.5)
Pupils adopt healthy lifestyles						
Exceptionally & consistently high	28.2 (23.6-32.7)	34.2 (29.5-38.9)	49.8 (44.1-55.6)*	27.1 (20.5-33.7)	48.6 (41.3-56.0)*	31.4 (23.6-39.2)
Generally above average	53.9 (48.9-59.0)	49.4 (44.4-54.3)	26.6 (21.5-31.7)*	50.3 (42.8-57.7)	48.1 (40.7-55.4)	62.1 (54.0-70.3)
Average/below average	17.9 (14.0-21.8)	16.5 (12.8-20.2)	23.6 (18.7-28.4)	22.6 (16.4-28.8)	3.3 (0.7-5.9)*	6.4 (2.3-10.5)*
Guidance and support						
Exceptionally & consistently high	37.9 (33.0-42.8)	47.0 (42.1-52.0)	67.3 (62.0-72.7)*	42.4 (35.0-49.7)	69.1 (62.3-75.9)*	41.4 (33.2-49.7)
Generally above average	60.3 (55.3-65.2)	48.1 (43.1-53.1)*	29.0 (23.8-34.1)*	45.8 (38.4-53.2)*	30.4 (23.6-37.2)*	55.7 (47.4-64.0)
Average/below average	1.8 (0.5-3.2)	4.9 (2.7-7.0)	3.7 (1.5-5.9)	11.9 (7.1-16.7)*	0.6 (0.0-1.6)	2.9 (0.06-5.7)
Progress of those with learning difficulties						
Exceptionally & consistently high	26.1 (21.6-30.5)	37.0 (32.2-41.8)*	66.0 (60.6-71.4)*	36.2 (29.0-43.3)	29.8 (23.1-36.6)	27.1 (19.7-34.6)
Generally above average	41.6 (36.6-46.6)	18.0 (14.2-21.8)*	14.8 (10.8-18.9)*	16.9 (11.4-22.5)*	36.5 (29.4-43.5)	23.6 (16.5-30.7)
Average/below average	31.8 (27.1-36.5)	44.2 (39.3-49.2)*	18.9 (14.4-23.3)*	44.1 (36.7-51.5)*	33.7 (26.7-40.7)	48.6 (40.2-57.0)
Exceptionally low	0.5 (0.0-1.3)	0.8 (0.0-1.6)	0.3 (0.0-1.0)	2.8 (0.4-5.3)	0	0.7 (0.0-2.1)

*Significantly different to White UK (non-overlapping confidence intervals)

4.1.5 Subjective opinion of teachers

The majority of pupils in every ethnic group said that they liked their teachers, ranging from 62.7% of Black Caribbean girls to 89.3% of Pakistani/Bangladeshi girls (Table 4.18). For both boys and girls, the Indians and Pakistani/Bangladeshis were the most likely to report liking their teachers. The proportion of pupils reporting that they had at least one teacher that encouraged them was high; over 80% in every group, and almost 90% for the Black Caribbean boys. There were no significant ethnic differences for this measure.

There were differences in these subjective measures by school type. Boys in single-sex schools were significantly more likely to say they had a teacher that encouraged them (OR 1.50, 95% CI: 1.20 to 1.88) and that they liked their teachers (OR 1.30, 1.10 to 1.53) than boys in mixed schools. Similarly, boys in Catholic schools were significantly more likely to report having a teacher who encouraged them (OR 1.76, 1.23 to 2.51) than boys in nondenominational schools; however they were significantly less likely to say they generally liked their teachers (OR 0.79; 0.63 to 0.99). Girls in single sex schools were significantly less likely to report liking their teachers than those in mixed schools (OR 0.78, 0.67 to 0.92). Furthermore, those in Church of England (OR 0.48, 0.38 to 0.61) and Catholic (OR 0.53, 0.44 to 0.63) schools were significantly less likely to like their teachers than those in non-denominational schools. However there were no significant differences by school type for teacher encouragement for the girls. It is interesting that although the all-girls schools were rated highly on many of the objective characteristics considered, they did not perform so well on the subjective measure of likeability of teachers.

The subjective school variables were aggregated to school level (separately for each sex); quartiles of these variables were derived. The Indian (65%) and Pakistani/Bangladeshi (46%) girls were the most likely to attend a school with a high proportion of pupils saying they liked their teachers (Q1). In contrast, only 15% of the White UK girls and 17% of the Indian boys attended such a school. The White UK boys were the most likely to attend a school in Q4; 49% of them did so. The Black Caribbean and Other African boys were the most likely to attend a school with a high proportion saying that at least one teacher encouraged them (Q1) and the Indian and Pakistani/Bangladeshi girls were the least likely.

Table 4.18 Subjective opinions of teachers by gender and ethnicity (14-16yrs)

	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys						
N	490	389	207	209	237	305
Individual level						
Like Teachers (%)	68.4 (64.2-72.5)	70.0 (65.3-74.5)	69.1 (62.7-75.4)	69.9 (63.6-76.1)	78.1 (72.8-83.4)*	77.7 (73.0-82.4)*
Teachers encourage me (%)	85.7 (82.6-88.8)	89.2 (86.1-92.3)	88.4 (84.0-92.8)	81.3 (76.0-86.7)	84.8 (80.2-89.4)	83.6 (79.4-87.8)
Aggregated to school level						
Like teachers						
Q1 (highest)	22.7 (18.9-26.4)	35.2 (30.5-40.0)*	19.3 (13.9-24.7)	32.1 (25.7-38.4)	39.2 (33.0-45.5)*	17.0 (12.8-21.3)
Q4 (lowest)	49.2 (44.7-53.6)	21.6 (17.5-25.7)*	16.9 (11.8-22.1)*	10.0 (5.9-14.2)*	15.2 (10.6-19.8)*	8.5 (5.4-11.7)*
Teachers encourage me						
Q1 (highest)	24.9 (21.1-28.7)	33.9 (29.2-38.7)*	24.2 (18.3-30.0)	34.0 (27.5-40.4)	27.0 (21.3-32.7)	19.0 (14.6-23.4)
Q4 (lowest)	30.8 (26.7-34.9)	18.8 (14.9-22.7)*	15.0 (10.1-19.9)*	26.3 (20.3-32.3)	9.7 (5.9-13.5)*	21.0 (16.4-25.6)
Girls						
N	380	389	297	177	181	140
Individual level						
Like Teachers (%)	74.2 (69.8-78.6)	62.7 (57.9-67.6)*	62.9 (57.4-68.5)*	66.7 (59.7-73.7)	85.6 (80.5-90.8)*	89.3 (84.1-94.5)*
Teachers encourage me (%)	86.6 (83.1-90.0)	82.0 (78.2-85.8)	83.2 (78.9-87.4)	82.5 (76.8-88.1)	80.7 (74.9-86.5)	82.1 (75.7-88.6)
Aggregated to school level						
Like teachers						
Q1	15.0 (11.4-18.6)	25.2 (20.9-29.5)*	8.4 (5.2-11.6)	27.1 (20.5-33.7)*	65.2 (58.2-72.2)*	46.4 (38.1-54.8)*
Q4	16.6 (12.8-20.3)	27.2 (22.8-31.7)*	27.3 (22.2-32.4)*	14.1 (8.9-19.3)	5.0 (1.8-8.2)*	3.6 (0.5-6.7)*
Teachers encourage me						
Q1 (highest)	31.3 (26.6-36.0)	31.1 (26.5-35.7)	30.0 (24.7-35.2)	24.3 (17.9-30.7)	14.9 (9.7-20.2)*	15.7 (9.6-21.8)*
Q4 (lowest)	22.6 (18.4-26.9)	21.6 (17.5-25.7)	15.2 (11.1-19.3)	22.6 (16.4-28.8)	43.1 (35.8-50.4)*	27.9 (20.3-35.4)

*Significantly different to White UK (non-overlapping confidence intervals)

4.1.6 Clustering of school characteristics

The school characteristics tended to cluster; for example the all-girls schools scored highly on many measures. Table 4.19 summarises how the schools which the ethnic minorities attended compared to the White UK pupils across the range of measures. It emphasises that, contrary to what may have been expected, the ethnic minority pupils in the DASH study often attended better schools than the White UK pupils, particularly with regards to school ethos and overall school performance. It is striking that compared to their White UK peers, the Nigerian/Ghanaian girls were significantly more likely to attend a school in the top category of all seven ethos measures, the Pakistani/Bangladeshi boys in six of them, and the Indian girls in five.

Of the 49 schools, some stand out as having relatively affluent pupils (as measured by low free school meal levels, high levels of academic success, and low truancy levels), good progress of those with learning difficulties, and a caring ethos. Of the 7 schools that score highly across this range of measures, all but one was a single-sex girls' school (the other was mixed sex). None of the 49 schools was in the lowest category for all of academic achievement, progress of those with learning difficulties, free school meals, ethos, and unauthorised absence, but some were in the lower quartiles for most of these measures. A more common pattern was that schools that scored poorly on deprivation, academic achievement and absenteeism, often had much higher scores for ethos.

Table 4.19 Summary of school characteristics by sex and ethnicity

	Boys[1]					Girls[1]				
	B.Car.	Nig./ Gha.	Oth. Afr.	Ind.	Pak./ Bang.	B.Car.	Nig./ Gha.	Oth. Afr.	Ind.	Pak./ Bang.
General characteristics										
Single sex	+	+	+		+	+	+			
Church of England				−		+	+		−	
Catholic	+	+	+	−		+	+	+	−	−
Highest spending							+		−	
Outstanding overall	+	+	+	+		+	+		+	
Social										
Lowest proportion English as 2nd language	−	−	−	−	−	−	−	−	−	−
SES										
Lowest free school meals	−	−	−			−		−		−
Lowest absenteeism	+			+		+	+		+	
Highest academic achievement			−		−		+			−
Lowest SEN				+						
Ethos										
Exceptionally high for:										
Overall personal development	+	+		+	+	+	+	+	+	+
Pupils Enjoy education				+	+		+		+	+
Pupil behaviour		+			+		+			
Spiritual, moral, social development						+	+		+	
Pupils adopt healthy lifestyles				+	+		+		+	
Pupils guided and supported	+			+	+		+		+	
Progress of those with learning difficulties		+			+	+	+			
Subjective opinions (school level)										
Highest proportion liking teachers	+			+		+		+	+	+
Highest proportion with encouraging teachers	+								−	−

[1]Significantly more (+) or less (−) likely to attend a school in this category than the White UK pupils. Empty cell if not significant.

4.1.7 Key points - School Environments

- The 49 schools in the DASH study provided very different environments for their pupils. They were diverse with regards to their pupil intake (e.g. sex, religion, ethnicity, SEN, SES), academic achievement, levels of absenteeism, and their ethos (including how committed and successful they were at developing and caring for their pupils).

- The schools were ethnically diverse; most of the DASH pupils attended a school where their fellow pupils were from a range of different ethnic backgrounds. Ethnic clustering was greatest for the White UK pupils, Indian boys, and Nigerian/Ghanaian girls.

- Of the boys, the Indians attended the least deprived schools. The Black Caribbean, Nigerian/Ghanaian, Other African and Pakistani/Bangladeshi boys tended to be in relatively deprived schools. For girls, the Nigerian/Ghanaians and Indians attended the least deprived schools; the Other Africans and Pakistani/Bangladeshis the most deprived.

- For many of the measures the all-girls schools performed better than the mixed and all-boys schools. Consequently, the ethnic groups most likely to attend these schools (e.g. Nigerian/Ghanaian girls) on average attended high-achieving schools relative to groups with high proportions attending mixed or all-boys schools.

- Pupils tended to view their teachers positively; high proportions of the DASH pupils in every ethnic group liked their teachers and felt they had at least one teacher who encouraged them.

4.2 Variance between schools and neighbourhoods in body size

Multilevel models were used to determine the proportion of variance in BMI SDS and Waist SDS due to differences between schools and between neighbourhoods. The girls were clustered in 41 schools and the boys in 40 schools. The number and size of clusters differed by ethnicity (schools Table 4.20; neighbourhoods Table 4.21). The number of schools that each ethnic group attended varied from 26 (Indian boys) to 40 (White UK boys and girls and Black Caribbean boys). The clustering by neighbourhood was more complex as pupils could belong to two different neighbourhoods if they had moved between the Waves of the study. In total the girls lived in 1011 different neighbourhoods (873 at Wave 1; 922 at Wave 2) and the boys in 1035 different neighbourhoods (928 at Wave 1; 951 at Wave 2).

Cluster sizes were therefore considerably larger for schools than neighbourhoods. For example, overall the largest school cluster for the girls was 112 pupils compared to the largest neighbourhood cluster of 9 pupils. Given that pupils could belong to more than one neighbourhood, the number of measurements per neighbourhood cluster was considered. A neighbourhood with 5 pupils living in it at both time points would have 10 measures associated with it; a neighbourhood with 3 pupils at 11-13yrs but only 1 pupil at 14-16yrs would have 4 measures associated with it.

Table 4.20 Summary of school clusters and pupils by gender and ethnic group

	Number of schools	Minimum no. pupils per school	Maximum no. pupils per school
Boys			
All	40	20	109
White UK	40	2	41
Black Caribbean	40	1	25
Nigerian/Ghanaian	37	1	25
Other African	35	1	15
Indian	26	1	38
Pakistani/Bangladeshi	32	1	53
Girls			
All	41	12	112
White UK	40	1	33
Black Caribbean	39	1	36
Nigerian/Ghanaian	32	1	57
Other African	35	1	14
Indian	29	1	38
Pakistani/Bangladeshi	28	1	26

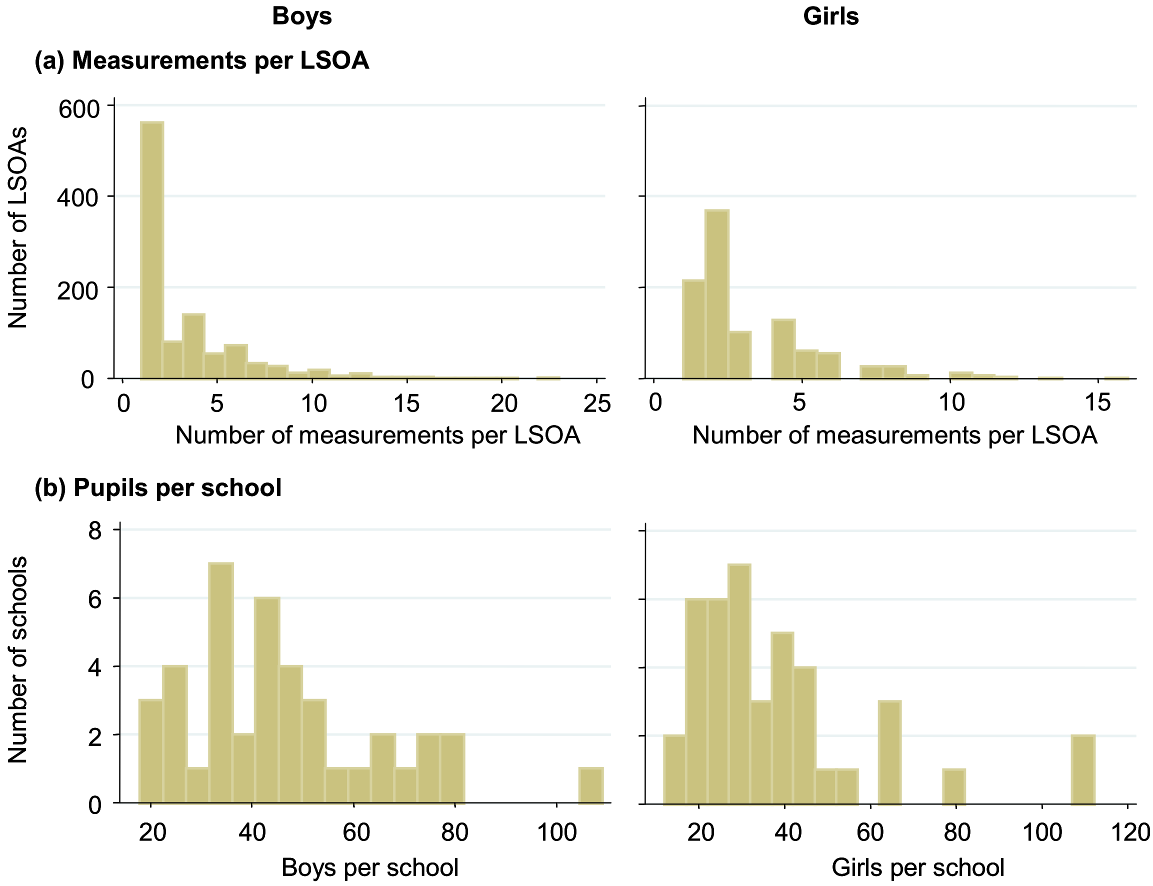
Table 4.21 Summary of number of neighbourhoods and pupils by ethnic group

	Number of neighbourhoods	Minimum no. pupils per neighbourhood	Maximum no. pupils (measurements) per neighbourhood
Boys			
All	1035	1	12 (23)
White UK	376	1	7 (13)
Black Caribbean	365	1	5 (8)
Nigerian/Ghanaian	206	1	3 (6)
Other African	226	1	5 (9)
Indian	190	1	4 (8)
Pakistani/Bangladeshi	232	1	7 (14)
Girls			
All	1011	1	9 (16)
White UK	327	1	5 (10)
Black Caribbean	380	1	4 (8)
Nigerian/Ghanaian	294	1	5 (9)
Other African	192	1	3 (6)
Indian	170	1	4 (8)
Pakistani/Bangladeshi	125	1	5 (10)

The distribution of the school and neighbourhood cluster sizes was positively skewed (Figure 4.8), particularly so for the neighbourhoods; a large proportion had small numbers of pupils living in them. For girls, 21.2% of the neighbourhoods had only one measurement and 36.4% had only two. For boys, the percentages were 16.8% and 37.6% respectively. For both boys and girls, the median number of measurements per neighbourhood was 2. In terms of the schools, for the girls there was a mean of 38.1 (95%

CI: 31.1 to 45.2) pupils per school (median of 30). For boys, the mean was 45.9 (39.6 to 52.2) and the median 43.

Figure 4.8 Distribution of cluster sizes by gender (LSOA and school)



Initial analysis considered what proportion of the variance in BMI SDS and Waist SDS was between schools or neighbourhoods for the whole sample (i.e. stratified by sex but not ethnicity). Results are presented first for BMI SDS then Waist SDS.

4.2.1 BMI SDS

4.2.1.1 Relative importance of the school and neighbourhood contexts

There was very little variation in BMI SDS at either the school or neighbourhood level (Table 4.22). In the models examining school and neighbourhood contexts separately, there was more variation between schools than between neighbourhoods; this was true for both the null models (adjusting for age only) and the baseline models (adjusting for age, pubertal status, height SDS and ethnicity). In the girls' null models, the proportion of variation in BMI SDS at the school level was greater than at the neighbourhood level (3.43% versus 0.30%). However in the girls' baseline model, and both the boys' null and baseline models, the difference between the proportion of variance at the school and neighbourhood level was considerably smaller.

There was more variation in BMI SDS between schools for girls than boys (3.43% compared to 0.89% in the null models, 0.96% compared to 0.32% in the baseline models). Results were less consistent for neighbourhood; there was more variation at the neighbourhood level for boys than girls in the null model (boys 0.58%, girls 0.30%) but in the baseline model the opposite was true (boys 0.23%, girls 0.59%).

Models were run with a cross-classification between school and neighbourhood to determine if results were consistent with when the contexts were examined individually in separate models. In general, the proportion of variance at school and neighbourhood level in the cross-classified model was slightly lower than it had been when each context was examined separately. For example, 0.89% of the variation in boys' BMI SDS was at the school level when school was the only context considered, however this fell to 0.74% when the neighbourhood context was also taken into consideration. Similarly, 0.58% of the variation was at neighbourhood level which fell to 0.32% when the school context was also included. This suggests that in the model with only school, some of the variance attributed to school was actually due to neighbourhood; conversely in the model with only neighbourhood some of the variance attributed to neighbourhoods was actually due to differences between schools.

The exception to this is the boys' baseline model where adjusting for the two contexts simultaneously actually resulted in the proportion of variance for each increasing compared to what was observed when the contexts were examined individually. This means there was more variation between schools when the neighbourhood context was taken into consideration than when it was not; and that there was more variation between neighbourhoods when school was taken into consideration than when it was not.

The total variance in BMI SDS was higher for boys than girls (1.88 versus 1.64 in the null model; 1.76 versus 1.52 in the baseline model). Adding height, pubertal status and ethnicity to the null models explained 6.4% of the variance in BMI SDS for boys, and 7.3% for girls.

Table 4.22 Percentage variation in BMI SDS at school and neighbourhood level

	Boys Variables in model		Girls Variables in model	
	Age (Null model)	Age, puberty, height, ethnicity (Baseline model)	Age (Null model)	Age, puberty, height, ethnicity (Baseline model)
Level 3: School				
% variance at school level	0.89	0.32	3.43	0.96
Level 3: Neighbourhood				
% variance at neighbourhood level	0.58	0.23	0.30	0.59
Level 3: School and neighbourhood				
% variance at school level	0.74	0.40	3.53	0.86
% variance at neighbourhood level	0.32	0.51	0.24	0.26
Total variance	1.88	1.76	1.64	1.52

4.2.1.2 Ethnic differences in BMI SDS variance

For both boys and girls, variance at the neighbourhood and school level was small in all ethnic groups. In every ethnic and gender group there was more variance between schools than between neighbourhoods (Boys Table 4.23; Girls Table 4.24). Also for both genders, the proportion of variance at the contextual level was lowest for the Indians (Boys: neighbourhood 0.15%, school 0.23%; Girls: neighbourhood 0.44%, school 0.84%) and highest for the Nigerian/Ghanaians (Boys: neighbourhood 0.31%, school 0.47%; Girls: neighbourhood 0.61%, school 1.14%). The amount of variance estimated at the measurement and individual level was similar in both the school and neighbourhood model for each ethnic group.

There were significant ethnic differences in the amount of variation both between measures and between individuals. For boys, the Indians had significantly more variation between measures (within individuals) than the White UK pupils (0.355 compared to 0.240 in the school model). Conversely the Black Caribbean and Nigerian/Ghanaian boys had significantly less variation between measures than the White UK boys. In terms of variance between individuals (within schools/neighbourhoods), there was significantly more variation between the Indians and Pakistani/Bangladeshis (school model only), and significantly less between the Nigerian/Ghanaians, compared to the White UK boys. For girls, there was significantly less variation between measures for the Nigerian/Ghanaians and Other Africans than the White UK girls. There was significantly more variation between individuals for the Black Caribbean, Indian and Pakistani/Bangladeshi girls than the White UK girls.

For boys, in every ethnic group the proportion of variance at the school level increased slightly and the proportion at the neighbourhood level decreased slightly when both contexts were in the model compared to when they were analysed separately. Variance estimates were similar in all three of the girls' models, and the proportion of variance at the school/neighbourhood level changed little whether these contexts were considered individually or simultaneously.

Table 4.23 Boys: Partitioning of variance by ethnicity - BMI SDS baseline model

	White UK	B. Car.	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
School level 3						
Variance - measures	0.240	0.161*	0.185*	0.282	0.355*	0.263
Variance-individuals	1.431	1.323	1.099*	1.261	2.217*	1.799*
Total variance[1]	1.677	1.490	1.290	1.549	2.578	2.068
% variance at school level	0.36	0.40	0.47	0.39	0.23	0.29
Neighbourhood Level 3						
Variance - measures	0.241	0.163*	0.188*	0.286	0.360*	0.266
Variance-individuals	1.441	1.323	1.100*	1.262	2.232*	1.804
Total variance[1]	1.686	1.490	1.292	1.552	2.596	2.074
% variance at neighbourhood level	0.24	0.27	0.31	0.26	0.15	0.19
School and Neighbourhood Cross Classified at Level 3						
Variance - measures	0.241	0.163	0.189*	0.286	0.361*	0.266*
Variance-individuals	1.433	1.322*	1.106*	1.262	2.230*	1.808
Total variance[1]	1.674	1.496	1.306	1.559	2.602	2.085
% variance at school level	0.48	0.53	0.61	0.51	0.31	0.53
% variance at neighbourhood level	0.18	0.20	0.23	0.19	0.12	0.14

[1]Total variance is the sum of measurement level variance, individual level variance and upper level variance [school =0.006 (0.008 in cross-classified model), neighbourhood =0.004 (0.003 in cross-classified model)].

*Amount of variance significantly different to White UK (p<0.05)

Table 4.24 Girls: Partitioning of variance by ethnicity - BMI SDS baseline model

	White UK	B. Car.	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
School level 3						
Variance - measures	0.208	0.184	0.156*	0.142*	0.216	0.201
Variance-individuals	1.099	1.515*	1.145	1.218	1.549*	1.544*
Total variance[1]	1.322	1.714	1.316	1.375	1.780	1.760
% variance school	1.13	0.88	1.14	1.09	0.84	0.85
Neighbourhood Level 3						
Variance - measures	0.210	0.185	0.158*	0.143*	0.222	0.207
Variance-individuals	1.132	1.546*	1.144	1.242	1.582*	1.578*
Total variance[1]	1.350	1.739	1.310	1.393	1.812	1.793
% variance neigh.	0.59	0.46	0.61	0.57	0.44	0.45
School and Neighbourhood Cross-classified at Level 3						
Variance - measures	0.209	0.184	0.157*	0.142*	0.221	0.208
Variance-individuals	1.101	1.525*	1.141	1.219	1.542*	1.540
Total variance[1]	1.333	1.732	1.321	1.384	1.786	1.771
% variance school	1.13	0.87	1.14	1.08	0.84	0.85
% variance neigh.	0.60	0.46	0.61	0.58	0.45	0.45

[1]Total variance is the sum of measurement level variance, individual level variance and upper level variance (school = 0.015, neighbourhood = 0.008). (Upper level variance was identical in models considering contexts individually and concurrently).

*Amount of variance significantly different to White UK ($p<0.05$)

4.2.1.3 Choice of method to model trends in BMI SDS

For the sample overall, very little of the variance in BMI SDS was at the contextual level for either girls or boys. The results of the partitioning of variance by ethnicity analysis confirmed this; in each ethnic group there was little variation at either contextual level, but there was slightly more at the school level than the neighbourhood level. Furthermore, the small proportion of variation at the neighbourhood level became even smaller if school was also included as a level in the model. It was therefore decided to model the data using only school at level 3 in further analysis.

Including only school at the contextual level in the model was pragmatic as it allowed analysis to be conducted using Stata (including neighbourhood as a level, whether alone or cross-classified with school, necessitates that MLwiN be used for the analysis). Being able to analyse the data in Stata rather than MLwiN had several practical advantages; models were considerably quicker to build, easier to store, and simple to edit. More details are provided in the Methods (Chapter 2).

4.2.2 Waist SDS

4.2.2.1 Relative importance of the school and neighbourhood contexts

As was the case with BMI SDS, there was very little variation in Waist SDS at either the school or neighbourhood level (Table 4.25). When the school and neighbourhood contexts were considered separately, the proportion of variance at the school level was greater than the proportion of variance at the neighbourhood level for both boys and girls, and in both the null and baseline models.

The proportion of variance at the school level in the girls' null model was 3.41%; a very similar value to that seen for BMI SDS (3.43%). However the addition of pubertal status, height SDS and ethnicity reduced the variance at school level to 0.96% for BMI SDS but to only 2.03% for Waist SDS. Therefore these covariates did not explain as great a proportion of the between school variation in Waist SDS as they did for BMI SDS. The proportion of variance in Waist SDS at the neighbourhood level was small (0.82%), but was greater than that observed for BMI SDS (0.30%). Adjusting for the additional covariates (pubertal status, height SDS and ethnicity) did not reduce the proportion of variation at school level for Waist SDS.

For boys, the proportion of variance in Waist SDS at school level (0.97%) was only slightly higher than that seen for BMI SDS (0.89%). The proportion at neighbourhood level was slightly lower for Waist SDS (0.52%) than BMI SDS (0.58%). Adjusting for pubertal status, height SDS and ethnicity actually increased the proportion of variance at the school level (from 0.97% to 1.42%), however this was still less than the proportion observed for the girls (2.03%). In contrast adjusting for these covariates reduced the proportion of variance at neighbourhood level from 0.52% to 0.20%.

For girls, the proportion of variance between schools was very similar whether school alone, or a cross-classification of school and neighbourhood, was included at the contextual level. In contrast, once the school context was also adjusted for, the proportion of variance at the neighbourhood level decreased. The picture was different for the boys; the proportion of variance at the school level decreased, and the proportion at the neighbourhood level increased, in the cross-classified school and neighbourhood model compared to when the two contexts were considered individually. Overall, adjusting for pubertal status, height and ethnicity explained 13.9% of the variance in Waist SDS variance for boys, and 12.3% for girls. Therefore the vast majority of the variance was not explained by these factors.

Table 4.25 Percentage variation in Waist SDS at school and neighbourhood level

	Boys		Girls	
	Age (Null model)	Age, puberty, height, ethnicity (Baseline model)	Age (Null model)	Age, puberty, height, ethnicity (Baseline model)
Level 3: School				
% variance at school level	0.97	1.42	3.41	2.03
Level 3: Neighbourhood				
% variance at neighbourhood level	0.52	0.20	0.82	0.82
Level 3: School and neighbourhood				
% variance at school level	0.23	0.34	3.58	1.98
% variance at neighbourhood level	0.86	1.28	0.51	0.35
Total variance	1.73	1.49	1.95	1.71

4.2.2.2 Ethnic differences in Waist SDS variance

For both boys and girls, the proportion of variance at the school and neighbourhood level was small for each ethnic group (Boys Table 4.26; Girls Table 4.27). For the boys, the proportion of variance at the school level was greater than the proportion at neighbourhood level in every ethnic group. For the girls, although the proportion of variance at the school level was greater than that at the neighbourhood level in every ethnic group, the difference between the two contexts was considerably smaller than that observed for the boys, primarily because the proportion of variance at the neighbourhood level was higher for the girls. Apart from the Pakistani/Bangladeshi girls, all of the groups had >1% of the variation in Waist SDS at the neighbourhood level. In contrast, none of the boys had even 0.5%.

For both boys and girls, it was the Indians who had the lowest proportion of variance in Waist SDS at both the neighbourhood and school level (Boys: 0.25% and 1.86% respectively; Girls: 0.89% and 1.64%), and the Nigerian/Ghanaians the highest (Boys: neighbourhood 0.43%, school 3.23%; Girls: neighbourhood 1.36%, school 2.41%).

For the boys, the Indians and Pakistani/Bangladeshis had significantly more variation between individuals (within neighbourhood/schools) than the White UK boys. The Nigerian/Ghanaians had less variation between individuals than the White UK boys; this was significant in the models with school, and school and neighbourhood at level 3, but not in the model with neighbourhood alone at level 3. Compared to the White UK boys, the Other African and Indian boys had greater variation between measures (within individuals); these differences were statistically significant in the model with neighbourhood at level 3 but not in the model with school at level 3.

There were fewer ethnic differences in the amount of variance between individuals and measurements for girls compared to boys. For the girls, none of the groups had an amount of variation between individuals which was significantly different to the White UK girls. The Nigerian/Ghanaian girls had significantly less variation between measures (within individuals) compared to the White UK girls.

Table 4.26 Boys: Partitioning of variance by ethnicity - Waist SDS baseline model

	White UK	B. Car.	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
School level 3						
Variance - measures	0.426	0.415	0.430	0.530	0.509	0.480
Variance-individuals	0.923	0.886	0.677*	0.719	1.447*	1.259*
Total variance[1]	1.386	1.338	1.144	1.286	1.993	1.776
% variance school	2.67	2.77	3.23	2.88	1.86	2.08
Neighbourhood Level 3						
Variance - measures	0.419	0.423	0.421	0.536*	0.547*	0.491
Variance-individuals	0.970	0.912	0.750	0.752	1.437*	1.343*
Total variance[1]	1.394	1.340	1.176	1.293	1.989	1.839
% variance neigh.	0.36	0.37	0.43	0.39	0.25	0.27
School and Neighbourhood Cross Classified at Level 3						
Variance - measures	0.422	0.425	0.418	0.538	0.547*	0.490
Variance-individuals	0.961	0.885	0.712*	0.717	1.412*	1.318*
Total variance[1]	1.410	1.337	1.157	1.282	1.986	1.835
% variance school	1.63	1.72	1.99	1.79	1.16	1.25
% variance neigh.	0.28	0.30	0.35	0.31	0.20	0.22

[1]Total variance is the sum of measurement level variance, individual level variance and upper level variance [in school =0.037 (0.023 in cross-classified model), neighbourhood =0.005 (0.004 in cross-classified model)].

*Amount of variance significantly different to White UK, $p<0.05$

Table 4.27 Girls: Partitioning of variance by ethnicity - Waist SDS baseline model

	White UK	B. Car.	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
School level 3						
Variance - measures	0.474	0.463	0.373*	0.552	0.590	0.542
Variance-individuals	1.078	1.331	1.004	1.042	1.450	1.396
Total variance[1]	1.586	1.828	1.411	1.628	2.074	1.972
% variance school	2.14	1.86	2.41	2.09	1.64	1.72
Neighbourhood Level 3						
Variance - measures	0.475	0.464	0.377*	0.563	0.603	0.559
Variance-individuals	1.122	1.362	1.000	1.016	1.509	1.397
Total variance[1]	1.616	1.845	1.396	1.598	2.131	1.975
% variance neigh.	1.18	1.03	1.36	1.19	0.89	0.96
School and Neighbourhood Cross Classified at Level 3						
Variance - measures	0.476	0.467	0.377*	0.565	0.600	0.559
Variance-individuals	1.074	1.329	0.992	1.016	1.446	1.402
Total variance[1]	1.600	1.846	1.419	1.631	2.096	1.961
% variance school	2.00	1.73	2.26	1.96	1.53	1.63
% variance neigh.	1.13	0.98	1.27	1.10	0.86	0.92

[1]Total variance is the sum of measurement level variance, individual level variance and upper level variance [in school =0.034 (0.032 in cross-classified model), neighbourhood =0.019(0.018 in cross-classified model)].

*Amount of variance significantly different to White UK, p<0.05

4.2.2.3 Choice of method to model trends in Waist SDS

For both boys and girls, and in every ethnic group, the proportion of variance at both the school and neighbourhood level decreased when the contexts were considered together in a cross-classified model compared to when they were analysed separately. Therefore for the boys, the proportion of variance at the neighbourhood level was low and became even lower once the school context was taken into account. Based on this stratified analysis, it was deemed appropriate to conduct further analysis with only school at level 3.

In some cases the proportion of variance at the neighbourhood level for girls was similar in magnitude to what was observed at school level for the boys. However, looking only within the girls, the school context accounts for a larger proportion of variation in Waist SDS than the neighbourhood context and this was therefore the justification for doing further analysis with only school at level 3.

4.2.3 Between school variation in body size

The finding that very little of the variance in body size (either BMI or Waist) was due to differences between schools suggests that there was little difference between schools in their mean BMI or Waist values. In order to confirm this, mean values by school were calculated and plots of the school-level residuals for BMI SDS and Waist SDS were produced in MLwiN.

4.2.3.1 BMI SDS

There was more variability in BMI SDS at the school level for girls than boys. For girls, the mean (unadjusted) school BMI SDS ranged from 0.04 (mean BMI of 20.1) to 1.15 (mean BMI of 23.8). The BMI SDS school-level residual (and 95% confidence interval) for each of the 41 schools that the girls attended is shown (Figure 4.9). In these figures each triangle represents the BMI SDS residual of a school and the vertical lines give the 95% confidence interval of this estimate. The horizontal dotted line at 0 is the overall sample mean. Four schools had BMIs significantly greater than the sample mean. Further investigation of the higher BMI schools revealed that many of them were single sex and/or religious schools (Table 4.28). Of the 7 schools with the highest school residuals for BMI SDS, 4 were all-girls schools, and 5 were religious schools (4 Roman Catholic, 1 Church of England). All of the schools had small numbers of South Asian pupils and most had relatively high proportions of Black Caribbean and/or Black African pupils. Therefore they tended to have relatively high numbers of pupils from the ethnic groups which had the highest mean BMIs.

As a comparison, the schools with the lowest BMI SDS residuals are also summarised; the 6 schools with the lowest residuals were all mixed sex, non-denominational schools. The main ethnic group in each of these schools was either White UK or a South Asian group; there were low proportions of the Black African and Caribbean groups in these schools.

Figure 4.9 Girls: BMI SDS residuals (95% CI) by school adjusted for age (Circled schools have BMI SDS significantly different from overall mean)

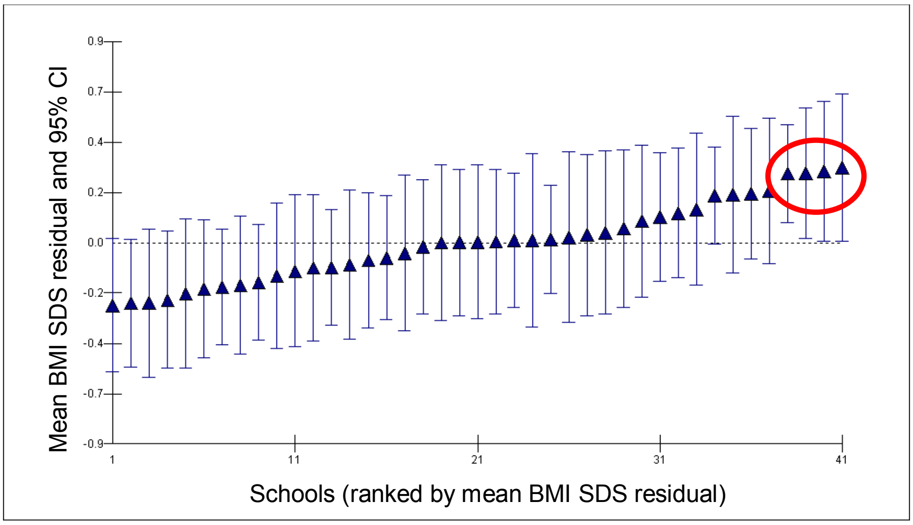
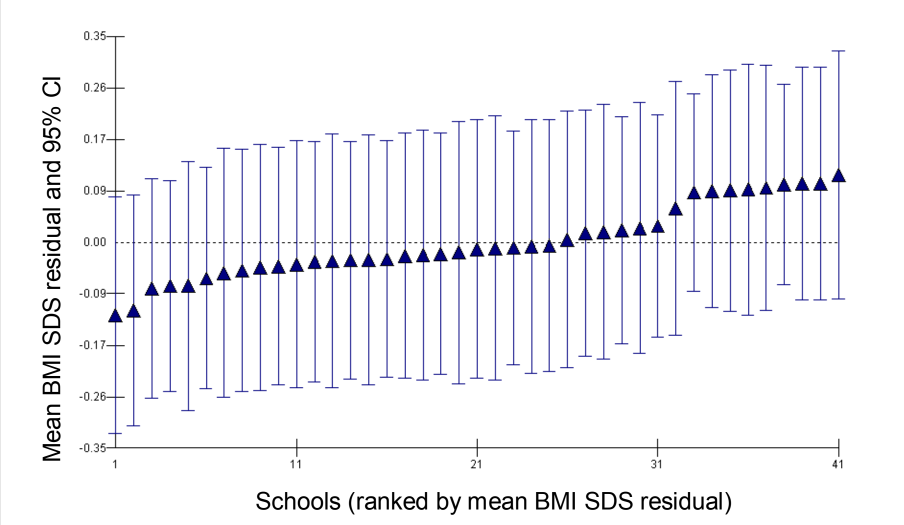


Table 4.28 Girls: Sex, religion and main ethnic group of high and low BMI schools

Rank	School sex	School religion	Largest ethnic group in DASH sample (% of DASH pupils in the school belonging to that ethnic group)
Highest mean BMI schools			
1 (highest)	Girls	Roman Catholic	Nigerian/Ghanaian (52%)
2	Mixed	Church of England	Black Caribbean (41%)
3	Girls	Roman Catholic	Nigerian/Ghanaian (36%)
4	Mixed	Non-denominational	White UK (45%)
5	Mixed	Roman Catholic	Black Caribbean, Nigerian/Ghanaian, Other African (all 29%)
6	Girls	Non-denominational	White UK, Black Caribbean (both 31%)
7	Girls	Roman Catholic	Nigerian/Ghanaian (43%)
Lowest mean BMI schools			
1 (lowest)	Mixed	Non-denominational	White UK (68%)
2	Mixed	Non-denominational	Indian (51%)
3	Mixed	Non-denominational	White UK (65%)
4	Mixed	Non-denominational	Indian (44%)
5	Mixed	Non-denominational	White UK (94%)
6	Mixed	Non-denominational	Pakistani/Bangladeshi (40%)

Adjustment for pupils' ethnicity, in addition to age, reduced the between school variability in BMI SDS; no schools had a mean BMI significantly different to the overall mean, and the difference between the lowest and highest BMI schools was much reduced (Figure 4.10). Therefore the ethnic composition of the DASH sample within each school explained much of the difference in schools' mean BMIs.

Figure 4.10 Girls: BMI SDS residuals (95% CI) by school adjusted for age and ethnicity



There was less variability in BMI SDS between schools for boys than girls; the mean school BMI SDS ranged from 0.06 (mean BMI of 19.3) to 0.83 (mean BMI of 21.7). This lack of variability is reflected in the plot of BMI SDS residuals by school; the residuals were smaller than those observed for the girls and none of the schools had a BMI SDS significantly different from the overall mean (Figure 4.11). Of the 5 schools with the highest BMI SDS residuals, 2 were single sex and 2 Catholic (Table 4.29). Therefore there was not such a clear clustering of single sex, religious schools as was seen for the girls. However in all but one of these 5 schools the largest ethnic group was Black Caribbean (3 schools) or Nigerian/Ghanaian (1 school); the two ethnic groups with the highest mean BMIs. In common with the girls, the low BMI schools were all mixed, non-denominational schools where the Indian or Pakistani/Bangladeshi pupils often formed the largest ethnic group. Therefore although there was less variability in BMI between schools for the boys than the girls, it seems likely that pupil ethnicity would explain much of the small amount of variation that did exist for the boys, as it did for the girls.

Figure 4.11 Boys: BMI SDS residuals (95% CI) by school adjusted for age

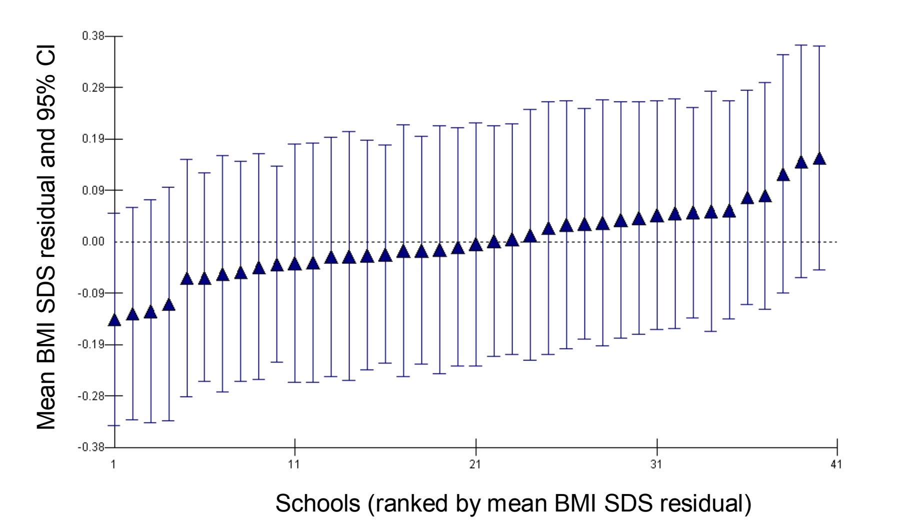
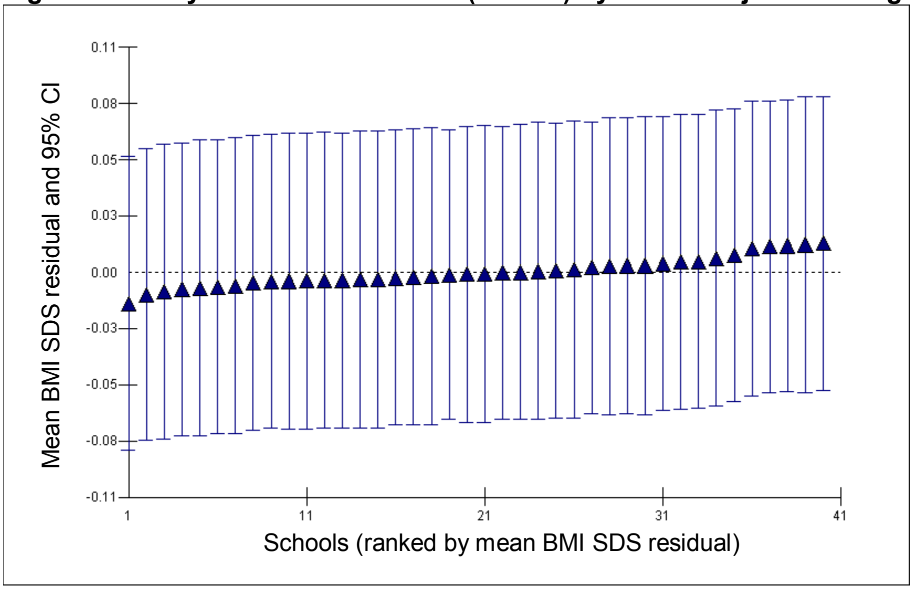


Table 4.29 Boy: Sex, religion and main ethnic group of high and low BMI schools

Rank	School sex	School religion	Largest ethnic group in DASH sample (% of DASH pupils in the school belonging to that group)
Highest mean BMI schools			
1 (highest)	Mixed	Non-denominational	Black Caribbean (35%)
2	Mixed	Catholic	Nigerian/Ghanaian (60%)
3	Mixed	Non-denominational	White UK (86%)
4	Boys	Catholic	Black Caribbean (50%)
5	Boys	Non-denominational	Black Caribbean (27%)
Lowest mean BMI schools			
1 (lowest)	Mixed	Non-denominational	Indian (51%)
2	Mixed	Non-denominational	Indian (39%)
3	Mixed	Non-denominational	White UK (73%)
4	Mixed	Non-denominational	Pakistani/Bangladeshi (59%)

The model was re-run, adjusting for ethnicity in addition to age. Including ethnicity in the model explained almost all of the between school variability in BMI SDS (Figure 4.12); therefore, as anticipated, much of the small amount of variation between schools that was present could be explained by the ethnicity of the DASH pupils.

Figure 4.12 Boys BMI SDS residuals (95% CI) by school adjusted for age and ethnicity



4.2.3.2 Waist SDS

For girls, the mean (unadjusted) school waist SD score ranged from 0.23 (mean waist circumference of 65.3cm) to 1.43 (73.4cm). Adjusting only for age, one school had a mean waist circumference significantly greater than the sample mean, with another three schools being borderline significant. At the other end of the spectrum, three schools had mean waist circumferences significantly less than the overall sample mean (Figure 4.13). Adjustment for ethnicity slightly reduced the differences in mean Waist SDS between the schools, however one school still had a mean waist circumference significantly greater than the mean, and one significantly less (Figure 4.14). This is in contrast to what was observed for BMI, where there were no significant differences between any of the schools and the overall sample mean after adjustment for age and ethnicity.

Figure 4.13 Girls: Waist SDS residuals (95% CI) by school, adjusted for age (Circled schools have Waist SDS significantly different from overall mean)

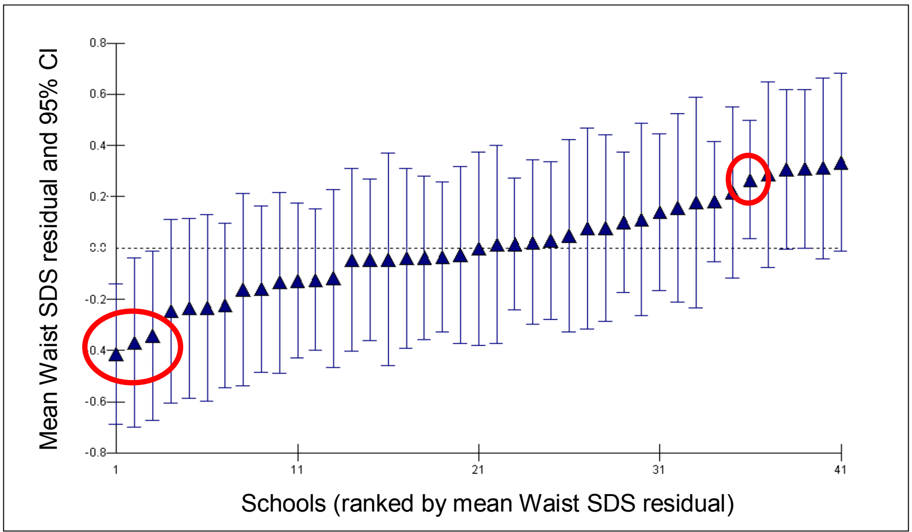
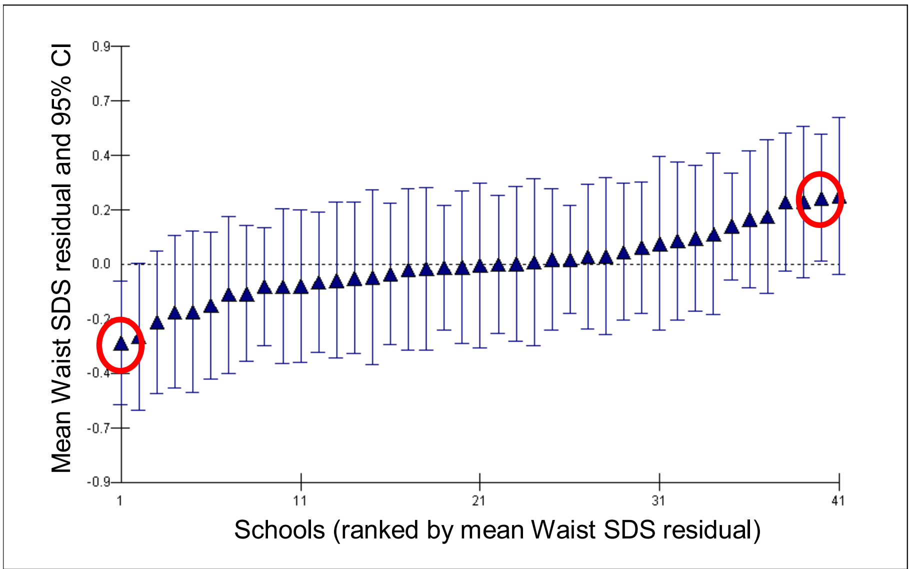


Figure 4.14 Girls: Waist SDS residuals (95% CI) by school, adjusted for age and ethnicity (Circled schools have Waist SDS significantly different from overall mean)



For boys, as expected given the small proportion of variation at the school level, there was little difference in mean Waist SDS between the schools. The mean (unadjusted) waist SD score by school ranged from -0.04 (mean waist circumference of 68.3cm) to 0.59 (71.7cm). The Waist SDS school level residuals for boys are shown adjusted only for age (Figure 4.15) and for age and ethnicity (Figure 4.16). No school had a mean waist circumference significantly different from the overall mean. Adjustment for the pupils' ethnicity reduced the variation between the schools slightly.

Figure 4.15 Boys: Waist SDS residuals (95% CI) by school, adjusted for age

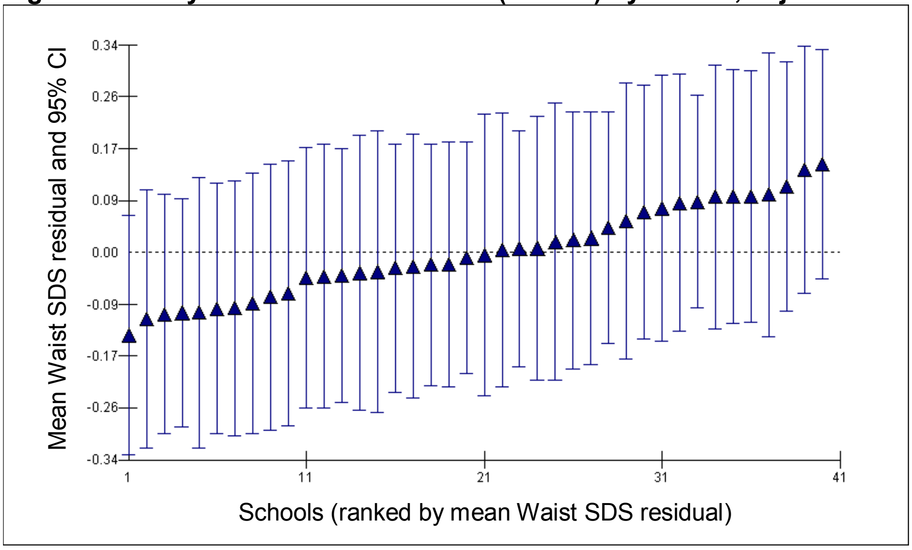
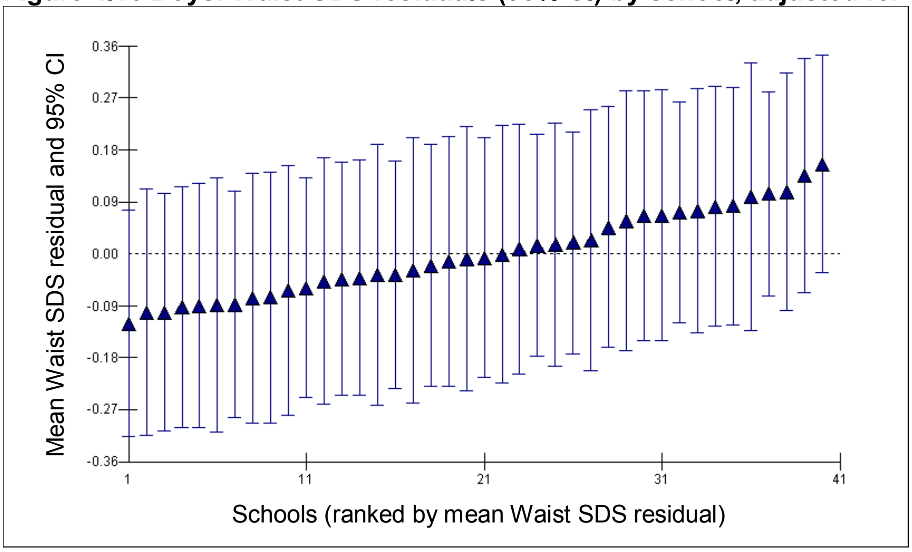


Figure 4.16 Boys: Waist SDS residuals (95% CI) by school, adjusted for age and ethnicity



4.3 The association between school characteristics and body size

Associations between school characteristics and BMI SDS and Waist SDS were examined. The aim was to determine whether any of the school characteristics were associated with the body size measures, and whether they could explain any of the between school variance observed.

Each variable was added individually to the baseline model (i.e. the model adjusting for age, height and pubertal status) and its significance in the model and impact on the between school variance were assessed. Models were then refitted with an interaction term between ethnicity and the variable being assessed; this was to determine whether the association between the given variable and the outcomes differed by ethnic group. Where this interaction was significant ($p<0.05$), models stratified by ethnicity were built to further examine ethnic differences in the association. All of the school contextual variables were added to the model as fixed effects; therefore any association between them and body size was assumed to be the same in all schools. Categorical variables were only considered to be significantly related to body size if there was a suggestion of a trend across categories. Each of the groups of characteristics is discussed in turn.

4.3.1 School type/general characteristics and body size

The general characteristics considered were: school type (sex and religion); school size (number of pupils); spending per pupil; and overall effectiveness. Results are presented in Table 4.30.

Table 4.30 Association between general school characteristics and body size

General school characteristics		Boys[1] BMI SDS	Boys[1] Waist SDS	Girls[1] BMI SDS	Girls[1] Waist SDS
School sex	Mixed	Ref	Ref	Ref	Ref
	All-boys	0.09 (-0.06-0.24)	-0.01 (-0.18-0.16)	0.18 (0.04-0.33)*	0.16 (-0.03-0.35)
School religion	Non-denominational	Ref	Ref	Ref	Ref
	Church of England	-0.14 (-0.51-0.23)	-0.27 (-0.65-0.11)	0.06 (-0.15-0.27)	0.03 (-0.26-0.33)
	Catholic	0.05 (-0.16-0.26)	-0.07 (-0.30-0.15)	0.28 (0.11-0.45)*	0.16 (-0.08-0.40)
School size	Q1 (smallest)	Ref	Ref	Ref	Ref
	Q2	-0.01 (-0.19-0.17)	-0.07 (-0.27-0.14)	0.17 (-0.02-0.36)	0.21 (-0.04-0.15)
	Q3	-0.01 (-0.19-0.17)	-0.02 (-0.22-0.19)	0.07 (-0.12-0.26)	0.09 (-0.15-0.33)
	Q4	-0.12 (-0.31-0.07)	-0.05 (-0.27-0.17)	-0.03 (-0.25-0.18)	-0.03 (-0.30-0.24)
Spending per pupil	Tertile 1 (highest)	Ref	Ref	Ref	Ref
	Tertile 2	-0.16 (-0.37-0.06)	-0.08 (-0.33-0.17)	0.22 (-0.03-0.47)	0.26 (-0.03-0.55)
	Tertile 3	-0.17 (-0.30--0.04)*	-0.09 (-0.25-0.07)	0.05 (-0.12-0.22)	0.08 (-0.12-0.28)
Overall effectiveness	Outstanding	Ref	Ref	Ref	Ref
	Good	0.04 (-0.14-0.23)	-0.03 (-0.24-0.18)	-0.11 (-0.29-0.08)	-0.15 (-0.37-0.07)
	Satisfactory	-0.08 (-0.26-0.11)	-0.15 (-0.36-0.05)	-0.05 (-0.22-0.12)	-0.08 (-0.29-0.13)
	Inadequate	-0.20 (-0.76-0.37)	0.08 (-0.49-0.66)	-0.13 (-0.86-0.59)	-0.37 (-1.17-0.43)

*Significantly different to reference category ($p<0.05$)

[1] Each of the school characteristics added individually to baseline model (adjusted for age, height SDS, pubertal status, and ethnicity).

The sex of the school (reference group: mixed) and religion (reference group: non-denominational) were not significantly related to BMI SDS for boys or for Waist SDS for girls or boys. Furthermore there were no significant interactions with ethnicity. However both school sex and religion were significantly related to BMI SDS for girls. Girls in single sex schools had higher BMI SD scores than those in mixed sex schools, and those in Catholic schools had higher BMI SD scores than those in non-denominational schools. There was no significant difference between those in Church of England schools compared to those in non-denominational ones. Interactions with ethnicity were not significant for either school sex or religion.

As many of the schools that were single sex were also religious, the girls' model was rerun including both of the school type variables simultaneously. School sex was not significantly related to BMI SDS once school religion was controlled for. The higher BMI SD scores of those in Catholic schools remained, with the effect size reducing slightly;

0.22 (0.03 to 0.40). A further variable was derived combining the school sex and religion variables, with the reference group being mixed-sex, non-denominational. Those in non-denominational all-girls schools had scores 0.29 (0.09 to 0.48) higher. The effect size for those in Church of England mixed schools was similar 0.32 (0.0 to 0.64). There was no significant difference between those in Church of England all-girls schools and the reference group. The girls in the Catholic mixed (0.31, 0.05 to 0.57) and Catholic girls' schools (0.33, 0.15 to 0.51) had significantly higher BMI SD scores. (The equivalent analysis for boys was conducted; there were no significant differences).

School sex and religion explained a large proportion of between school variance in BMI SDS for the girls (49% and 70% respectfully) although the absolute amount was small (Table 4.31). The proportion of between school Waist SDS variance explained by school type was less than that seen for BMI SDS. For boys, adjustment for school religion increased the variation between schools for the boys by almost 13%.

Table 4.31 Proportion of BMI SDS and Waist SDS variance explained by School Sex and Religion

		% variance explained by each model	
	Variance (Baseline)	School sex	School religion
BMI SDS			
Boys			
School	0.006	9.19	-12.98
Individual	1.517	0.01	-0.03
Measurement	0.239	0.00	0.00
Total	1.762	0.04	-0.06
Girls			
School	0.015	49.27	70.16
Individual	1.317	-0.07	-0.07
Measurement	0.186	0.00	0.00
Total	1.517	0.42	0.61
Waist SDS			
Boys			
School	0.022	-6.50	1.06
Individual	1.055	0.00	0.02
Measurement	0.479	0.00	-0.01
Total	1.556	-0.09	0.02
Girls			
School	0.036	10.70	0.13
Individual	1.245	-0.03	-0.04
Measurement	0.504	0.00	0.01
Total	1.785	0.20	-0.02

There was no significant association between the size of the school (number of pupils), or the overall effectiveness of the school, and BMI SDS or Waist SDS for either boys or girls. Interactions with ethnicity were also not significant. The relationship between spending per pupil and Waist SDS was not significant for either boys or girls, however the association with BMI SDS was significant for boys. Boys in schools with the lowest spending per pupil had significantly lower BMI SD scores than those in schools with the highest spending. Those in the middle tertile also had lower scores but not significantly so. This variable accounted for 84% of between school variation in BMI SDS for boys.

4.3.2 Social environment and body size

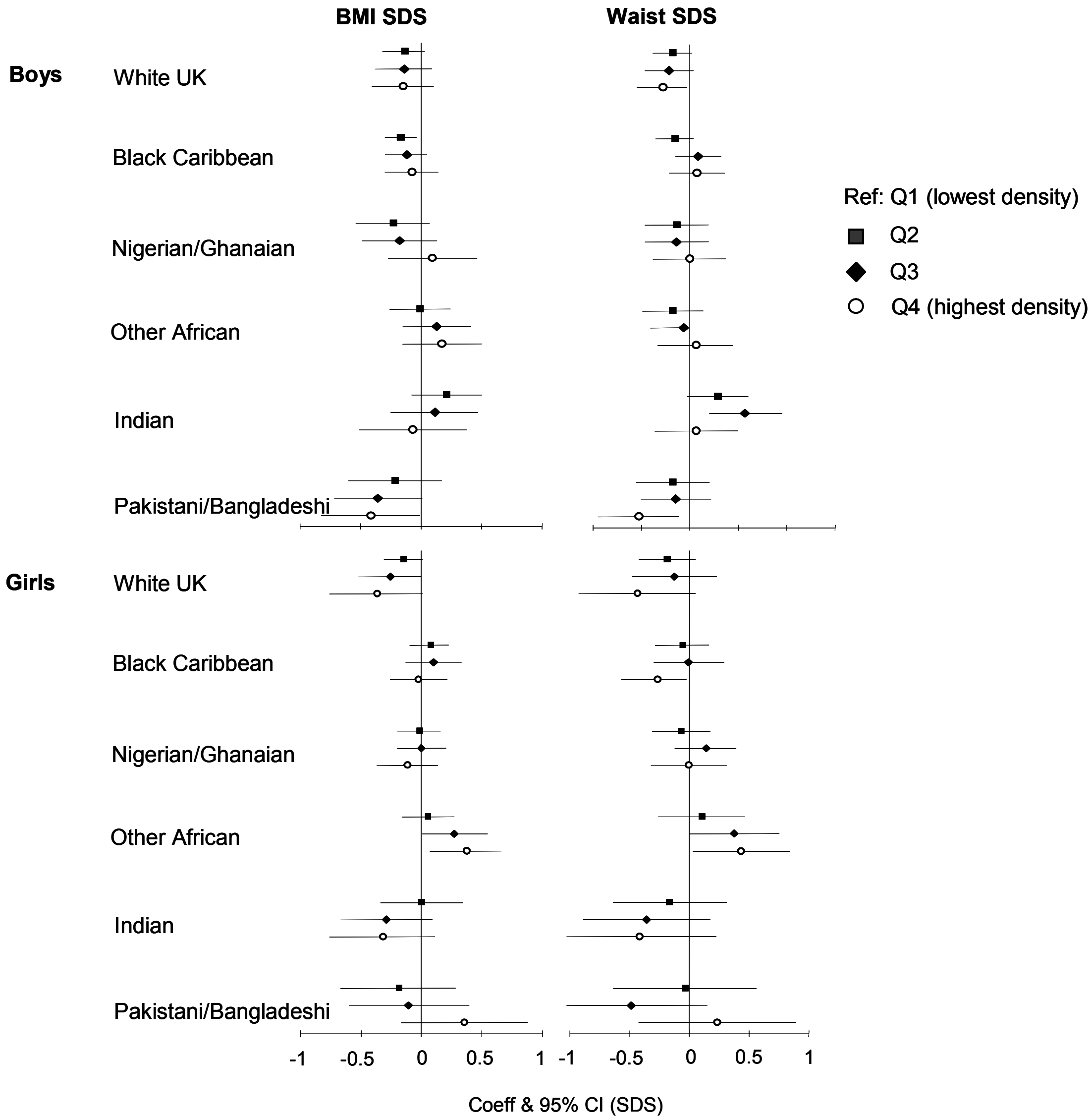
The association between own ethnic density and body size was explored for each ethnic group e.g. the association between school-level White UK density and body size for White UK pupils, school-level Black Caribbean density and body size for Black Caribbean pupils etc. The association between Non-White UK density and body size was analysed for the overall sample, and interactions with ethnicity tested. Associations with the proportion speaking English as a second language were explored. Results are presented in Table 4.32 and Figure 4.17.

Table 4.32 Sociocultural environment of the school and body size

School level own ethnic density		Boys[1] BMI SDS	Boys[1] Waist SDS	Girls[1] BMI SDS	Girls[1] Waist SDS
White UK density	Q1 (lowest)	Ref	Ref	Ref	Ref
	Q2	-0.14 (-0.32-0.03)	-0.18 (-0.38-0.02)	-0.15 (-0.31-0.01)	-0.19 (-0.42-0.05)
	Q3	-0.14 (-0.38-0.09)	-0.22 (-0.47-0.03)	-0.26 (-0.52-0.00)	-0.13 (-0.48-0.23)
	Q4	-0.15 (-0.41-0.10)	-0.28 (-0.54--0.03)*	-0.37 (-0.76-0.01)	-0.44 (-0.93-0.05)
Black Caribbean density	Q1 (lowest)	Ref	Ref	Ref	Ref
	Q2	-0.17 (-0.30--0.04)*	-0.16 (-0.36-0.03)	0.07 (-0.10-0.22)	-0.06 (-0.29-0.16)
	Q3	-0.12 (-0.30-0.05)	0.08 (-0.15-0.32)	0.10 (-0.13-0.33)	-0.01 (-0.30-0.29)
	Q4	-0.08 (-0.30-0.14)	0.07 (-0.22-0.36)	-0.03 (-0.26-0.21)	-0.27 (-0.57-0.03)
Nigerian/Ghanaian	Q1 (lowest)	Ref	Ref	Ref	Ref
	Q2	-0.23 (-0.54-0.07)	-0.14 (-0.47-0.19)	-0.02 (-0.20-0.16)	-0.07 (-0.31-0.17)
	Q3	-0.18 (-0.49-0.13)	-0.14 (-0.47-0.19)	-0.00 (-0.20-0.20)	0.14 (-0.12-0.39)
	Q4	0.09 (-0.27-0.46)	-0.01 (-0.38-0.37)	-0.12 (-0.37-0.13)	-0.01 (-0.32-0.31)
Other African	Q1 (lowest)	Ref	Ref	Ref	Ref
	Q2	-0.01 (-0.26-0.24)	-0.18 (-0.49-0.13)	0.05 (-0.16-0.27)	0.10 (-0.26-0.46)
	Q3	0.13 (-0.15-0.41)	-0.07 (-0.41-0.27)	0.27 (0.01-0.54)*	0.37 (-0.00-0.75)
	Q4	0.17 (-0.15-0.50)	0.06 (-0.33-0.44)	0.37 (0.07-0.66)*	0.43 (0.03-0.84)*
Indian	Q1 (lowest)	Ref		Ref	Ref
	Q2	0.21 (-0.08-0.50)	0.28 (-0.03-0.60)	0.00 (-0.34-0.34)	-0.17(-0.64-0.31)
	Q3	0.11 (-0.25-0.47)	0.57 (0.20-0.95)*	-0.29 (-0.67-0.09)	-0.36 (-0.89-0.17)
	Q4	-0.07 (-0.51-0.37)	0.06 (-0.37-0.49)	-0.32 (-0.76-0.11)	-0.42 (-1.06-0.22)
Pakistani/Bangladeshi	Q1 (lowest)	Ref	Ref	Ref	Ref
	Q2	-0.22 (-0.60-0.17)	-0.18 (-0.56-0.20)	-0.19 (-0.67-0.28)	-0.04 (-0.64-0.56)
	Q3	-0.36 (-0.72-0.01)	-0.15 (-0.51-0.22)	-0.11 (-0.60-0.39)	-0.49 (-1.12-0.15)
	Q4	-0.42 (-0.83--0.01)*	-0.53 (-0.95--0.12)*	0.35 (-0.17-0.87)	0.23 (-0.43-0.89)
Non-White UK	Q1 (lowest)	Ref	Ref	Ref	Ref
	Q2	0.04 (-0.10-0.17)	-0.01 (-0.18-0.16)	0.14 (-0.04-0.32)	-0.02 (-0.28-0.25)
	Q3	0.06 (-0.09-0.20)	-0.10 (-0.28-0.08)	0.08 (-0.10-0.26)	0.06 (-0.19-0.32)
	Q4	0.05 (-0.11-0.21)	0.02 (-0.17-0.21)	0.15 (-0.05-0.34)	0.40 (0.11-0.68)
Pupils speaking English as a 2nd language	Q1 (lowest)	Ref	Ref	Ref	Ref
	Q2	0.02 (-0.07-0.10)	-0.07 (-0.18-0.05)	0.03 (-0.05-0.11)	0.08 (-0.05-0.20)
	Q3	0.03 (-0.09-0.15)	-0.07 (-0.23-0.08)	0.07 (-0.05-0.18)	-0.10 (-0.27-0.07)
	Q4	-0.08 (-0.20-0.05)	-0.08 (-0.24-0.08)	0.09 (-0.04-0.22)	0.07 (-0.11-0.25)

*Significantly different to reference category ($p<0.05$) [1] Each of the variables added individually to baseline model (adjusted for age, height SDS, pubertal status, and ethnicity).

Figure 4.17 Association between school own ethnic density and body size



There was a suggestion of a trend in the association between school White UK density and BMI SDS for White UK girls; higher White UK density being associated with lower BMI SD scores. However none of the differences reached statistical significance. A similar pattern was observed for Waist SDS. For boys, an increase in school White UK density was associated with a lower mean Waist SDS, but not BMI SDS.

School-level own ethnic density was not a significant correlate of either body size measure for Black Caribbean boys or girls. For Other African girls, a higher proportion of Black Africans in a school was associated with a higher BMI SDS and Waist SDS. In contrast, there was no association between Black African density in a school and body size for Other African boys. Furthermore Black African density was not associated with either body size measure for Nigerian/Ghanaian boys or girls.

For Indian girls, there was a suggestion of a trend of increasing school Indian density being associated with a decrease in Waist SDS but there were no statistically significant differences. Those in Q3 and Q4 also had lower BMI SD scores but again differences were not significant. In contrast, Indian boys in Q2, Q3 and Q4 had higher Waist SD scores than those in Q1, however this was significant only for those in Q3 and there was no indication of a trend. There was no significant association with BMI SDS.

A greater proportion of Pakistani/Bangladeshis in a school was associated with lower BMI and Waist SD scores for Pakistani/Bangladeshi boys, particularly for BMI SDS where there was a suggestion of a trend across the density quartiles. There was no association between Pakistani/Bangladeshi density in schools and body size for Pakistani/Bangladeshi girls.

The proportion of non-White UK pupils in a school was not associated with either body size measure for boys and there were no significant interactions with ethnicity. For girls, compared to those in schools with the lowest proportion of non-White UK pupils (Q1), those in Q4 had significantly higher Waist SD scores but there was no significant difference between those in Q2 or Q3 and those in Q1. There was no significant association between non-White UK density and BMI SDS for girls, and no significant interaction with ethnicity for either body size measure.

The proportion of children speaking English as a second language was unrelated to BMI SDS and Waist SDS for both boys and girls and there were no significant interactions with ethnicity.

The proportion of BMI SDS variance explained by Non-White UK density in a school was small (Table 4.33). The impact on Waist SDS variance was considerably larger; it increased school level variance by almost 30% for boys, and over 125% for girls. The impact on total Waist SDS variance was small. Including speaking English as a second language in the models explained over 30% of the between school variance in BMI SDS for boys, but increased it by over 18% for girls. The impact on Waist SDS variance was smaller.

Table 4.33 Proportion of BMI SDS and Waist SDS variance explained by Ethnicity and Language Use

	Variance (Baseline)	% variance explained by each model: Non-White UK Density	% variance explained by each model: English as 2nd Language
BMI SDS			
Boys			
School	0.006	1.82	30.78
Individual	1.517	0.03	-0.01
Measurement	0.239	-0.15	0.06
Total	1.762	0.01	0.10
Girls			
School	0.015	-4.15	-18.73
Individual	1.317	0.03	-0.01
Measurement	0.186	0.15	0.06
Total	1.517	0.01	-0.18
Waist SDS			
Boys			
School	0.022	-28.29	-7.52
Individual	1.055	-0.13	-0.06
Measurement	0.479	0.45	0.02
Total	1.556	-0.35	-0.14
Girls			
School	0.036	-125.62	-4.38
Individual	1.245	-0.26	-0.06
Measurement	0.504	1.64	0.44
Total	1.785	-2.28	-0.01

4.3.3 Socio-economic status and body size

Three proxy measures of school deprivation were considered: proportion of pupils receiving free school meals, academic performance, and unauthorised absence rates. The quartile form of all of these variables was used in the models. Results are presented in Table 4.34.

Table 4.34 School socio-economic status and body size

		Boys[1]		Girls[1]	
		BMI SDS	Waist SDS	BMI SDS	Waist SDS
School SES					
Unauthorised absence	Q1 (lowest)	Ref	Ref^	Ref^	Ref^
	Q2	-0.04 (-0.10-0.03)	-0.07 (-0.15-0.02)	-0.01 (-0.09-0.07)	0.09 (-0.03-0.22)
	Q3	-0.04 (-0.11-0.04)	-0.01 (-0.11-0.09)	-0.00 (-0.09-0.08)	0.10 (-0.03-0.23)
	Q4	-0.05 (-0.14-0.04)	0.17 (0.05-0.29)*	-0.01 (-0.11-0.09)	0.26 (0.11-0.42)*
Free school meals	Q1 (lowest)	Ref	Ref	Ref	Ref
	Q2	0.06 (-0.02-0.14)	-0.06 (-0.16-0.05)	0.06 (-0.03-0.15)	0.31 (0.17-0.44)*
	Q3	0.06 (-0.05-0.17)	-0.16 (-0.29--0.02)*	-0.04 (-0.15-0.07)	0.16 (-0.01-0.32)
	Q4	0.06 (-0.06-0.19)	0.03 (-0.11-0.18)	-0.08 (-0.22-0.05)	-0.09 (-0.28-0.10)
Academic Performance	Q1 (highest)	Ref	Ref	Ref^	Ref^
	Q2	0.10 (-0.05-0.25)	-0.00 (-0.19-0.18)	-0.10 (-0.20-0.00)	-0.05 (-0.20-0.10)
	Q3	0.13 (-0.02-0.29)	0.13 (-0.06-0.33)	-0.10 (-0.23-0.02)	0.04 (-0.15-0.22)
	Q4	0.13 (-0.03-0.29)	0.03 (-0.17-0.23)	-0.08 (-0.21-0.05)	0.01 (-0.18-0.19)
Special Educational Needs (with statements)	Q1 (lowest)	Ref	Ref	Ref	Ref
	Q2	0.01 (-0.05-0.07)	-0.07 (-0.15-0.01)	-0.03 (-0.10-0.05)	0.13 (0.01-0.25)*
	Q3	0.03 (-0.03-0.10)	-0.16 (-0.25--0.07)*	-0.04 (-0.12-0.05)	0.06 (-0.08-0.20)
	Q4	-0.04 (-0.12-0.05)	0.07 (-0.05-0.18)	-0.12 (-0.22--0.02)*	0.13 (-0.02-0.29)

*Significantly different to reference category (p<0.05)

[1] Each of the school characteristics added individually to baseline model (adjusted for age, height SDS, pubertal status, and ethnicity).

^ Significant interaction between variable and ethnicity. P-values for the interaction terms are given below, full details in text.

Unauthorised absence: Boys Waist SDS p=0.025; Girls BMI SDS p=0.004, Waist SDS p=0.031

Academic performance: Girls BMI SDS p=0.010, Waist SDS p=0.012

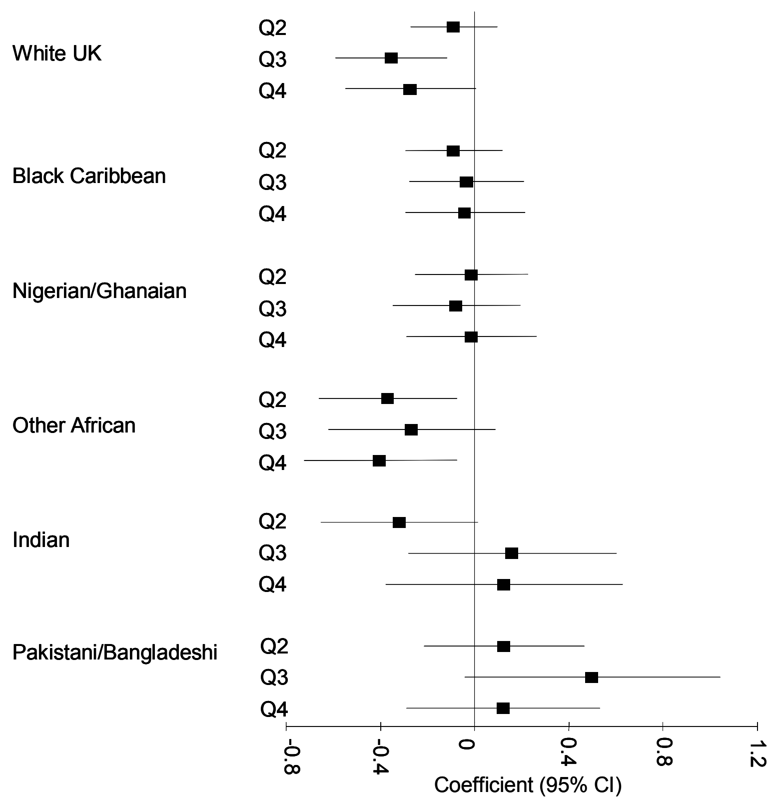
Overall both boys and girls in schools with the highest rates of unauthorised absence had a higher Waist SDS but not BMI SDS. However interactions with ethnicity were significant for Waist SDS for both genders and BMI SDS for girls. In analyses stratified by ethnicity, unauthorised absence was associated with Waist SDS for the Pakistani/Bangladeshi girls only; those in schools with the most unauthorised absence had Waist SD scores 0.66 (0.24 to 1.08) higher than those in schools with the least absence. There was no clear pattern between unauthorised absence and Waist SDS for any of the boys' groups, or with BMI SDS for any of the girls' groups.

There were significant differences between some of the free school meal quartiles and Waist SDS for both boys and girls, but there was no clear pattern. It therefore seems likely that these are chance findings rather than evidence of a real association between the proportion of free school meals and waist circumference. There was no association with BMI SDS. There were no significant interactions with ethnicity.

How well a school performed academically was not related to BMI SDS or Waist SDS for boys or girls in the overall samples, however an interaction with ethnicity was significant for the girls for both outcomes (p=0.01 for both). The association between a school's academic performance and BMI SDS was significant only for the White UK and Other African girls (Figure 4.18). For the White UK girls, those attending a school in Q3 had significantly lower BMI SD scores than those in the highest performing schools academically (Q1). For the Other Africans, it was those in Q2 and Q4 who had significantly lower scores. In stratified analysis for Waist SDS, academic performance was significant only for Indian girls; those in Q2 had significantly lower SD scores than those in the highest performing schools (-0.55, -0.95 to -0.16).

Figure 4.18 Girls: association between schools' academic performance and BMI SDS

(ref: Q1, highest academic performance). Adjusted for age, pubertal status and height SDS.



Academic performance explained 9% of the between school variability in BMI SDS for girls and 14% for boys (Table 4.35). Free school meals explained almost 20% of the between school variability for girls. For Waist SDS, free school meals explained 39% of between school variance for boys, but increased between school variance by almost 15% for girls.

Table 4.35 Proportion of BMI SDS and Waist SDS variance explained by School SES

		% variance explained by each model		
	Variance (Baseline)	Free school meals	Academic Performance	Unauthorised absence
BMI SDS				
Boys				
School	0.006	-6.14	13.87	11.00
Individual	1.517	-0.01	-0.01	-0.01
Measurement	0.239	-0.01	-0.02	-0.09
Total	1.762	-0.03	0.03	0.02
Girls				
School	0.015	19.54	9.48	9.59
Individual	1.317	0.03	-0.25	-0.06
Measurement	0.186	-0.08	1.13	0.94
Total	1.517	0.20	0.02	0.16
Waist SDS				
Boys				
School	0.022	38.68	-5.25	18.88
Individual	1.055	-0.06	-0.09	-0.66
Measurement	0.479	0.11	0.34	1.62
Total	1.556	0.55	-0.03	0.32
Girls				
School	0.036	-14.50	7.25	0.75
Individual	1.245	-0.36	-0.45	-0.33
Measurement	0.504	1.81	0.99	1.40
Total	1.785	-0.04	0.12	0.18

Related to academic performance is the proportion of pupils in a school with special educational needs (SEN). The BMI SDS of girls was significantly related to the proportion of pupils in a school with SEN with statements; those in schools with the highest proportion with SEN (Q4) had significantly lower BMI SD scores than those in schools with the lowest (Q1). The proportion of pupils in a school with special educational needs with statements was related to Waist SDS for both boys and girls but the lack of a clear pattern across categories meant there was little evidence of this being a true association.

4.3.4 School ethos and body size

None of the ethos variables were significantly related to BMI SDS for either boys or girls and there were no significant interactions with ethnicity (Table 4.36). The majority of the school ethos variables were not significantly associated with Waist SDS either; guidance and support was the only one which was (for boys only). Boys in schools ‘slightly above average' and 'average to below average' had significantly lower Waist SD scores than those in schools rated as 'exceptional'.

Table 4.36 School Ethos and Body Size

		Boys[1] BMI SDS	Boys[1] Waist SDS	Girls[1] BMI SDS	Girls[1] Waist SDS
Overall personal development & well-being	Exceptionally high	Ref	Ref	Ref	Ref
	Above average	0.08 (-0.05-0.21)	0.01 (-0.15-0.16)	-0.07 (-0.22-0.09)	-0.16 (-0.34-0.02)
	Average/below average	-0.17 (-0.38-0.04)	-0.14 (-0.38-0.11)	-0.10 (-0.37-0.17)	-0.06 (-0.37-0.26)
Spiritual, social, moral & cultural development	Exceptionally high	Ref	Ref	Ref	Ref
	Above average	0.08 (-0.06-0.22)	0.03 (-0.13-0.20)	-0.06 (-0.23-0.10)	-0.13 (-0.33-0.07)
	Average/below average	-0.12 (-0.29-0.05)	-0.10 (-0.30-0.10)	-0.18 (-0.38-0.02)	-0.14 (-0.38-0.11)
Behaviour of pupils	Exceptionally high	Ref	Ref	Ref	Ref
	Above average	0.03 (-0.12-0.17)	0.04 (-0.13-0.20)	-0.08 (-0.24-0.07)	-0.11 (-0.30-0.08)
	Average/below average	-0.09 (-0.29-0.11)	-0.03 (-0.25-0.18)	-0.11 (-0.35-0.12)	-0.14 (-0.42-0.15)
Progress of those with learning difficulties	Exceptionally high	Ref	Ref	Ref	Ref
	Above average	-0.00 (-0.18-0.17)	-0.00 (-0.20-0.19)	-0.08 (-0.27-0.11)	-0.10 (-0.34-0.13)
	Average/below average	-0.08 (-0.27-0.11)	-0.12 (-0.32-0.09)	-0.01 (-0.19-0.16)	-0.05 (-0.26-0.17)
	Exceptionally low	-0.21 (-0.78-0.36)	0.12 (-0.45-0.70)	-0.11 (-0.85-0.62)	-0.35 (-1.16-0.47)
How much pupils enjoy their education	Exceptionally high	Ref	Ref	Ref	Ref
	Above average	0.02 (-0.12-0.16)	-0.08 (-0.23-0.08)	-0.02 (-0.18-0.14)	-0.13 (-0.32-0.06)
	Average/below average	-0.08 (-0.29-0.13)	-0.12 (-0.35-0.11)	-0.10 (-0.35-0.15)	-0.10 (-0.39-0.20)
How much pupils adopt healthy lifestyles	Exceptionally high	Ref	Ref	Ref	Ref
	Above average	0.11 (-0.08-0.29)	-0.17 (-0.38-0.05)	-0.12 (-0.28-0.03)	-0.19 (-0.38-0.00)
	Average/below average	0.16 (-0.07-0.40)	-0.10 (-0.36-0.17)	0.03 (-0.17-0.24)	0.00 (-0.25-0.25)
Guidance and support	Exceptionally high	Ref	Ref	Ref	Ref
	Above average	-0.10 (-0.25-0.05)	-0.19 (-0.34--0.03)*	0.03 (-0.12-0.18)	-0.05 (-0.23-0.14)
	Average/below average	-0.20 (-0.44-0.05)	-0.35 (-0.59--0.10)*	0.07 (-0.29-0.42)	-0.15 (-0.56-0.26)

*Significantly different to reference category ($p<0.05$)

[1] Each of the school characteristics added individually to baseline model (adjusted for age, height SDS, pubertal status, and ethnicity).

4.3.5 Subjective opinion of teachers and body size

Liking teachers and having encouraging teachers variables were first included as individual covariates. Quartiles of the aggregate form of these variables were then analysed, the aim being to determine if there was a contextual effect on body size of attending a school where a high proportion of pupils liked their teachers or felt encouraged by their teachers. Results are presented in Table 4.37.

Table 4.37 Subjective opinion of teachers and body size

		Boys[1] BMI SDS	Boys[1] Waist SDS	Girls[1] BMI SDS	Girls[1] Waist SDS
Like teachers					
Individual level	Like teachers	Ref	Ref	Ref	Ref
	Dislike teachers	-0.24 (-0.37--0.11)*	-0.25 (-0.37--0.13)*	-0.02 (-0.15-0.12)	-0.11 (-0.25-0.03)
School level	Q1 (highest liking teachers)	Ref	Ref	Ref	Ref
	Q2	-0.13 (-0.31-0.05)	-0.15 (-0.34-0.04)	0.02 (-0.18-0.22)	-0.10 (-0.34-0.13)
	Q3	0.01 (-0.17-0.19)	0.02 (-0.18-0.21)	-0.10 (-0.31-0.10)	-0.12 (-0.37-0.12)
	Q4	-0.14 (-0.32-0.05)	-0.19 (-0.38-0.00)	0.24 (0.02-0.46)*	0.22 (-0.05-0.48)
Encouraging teacher					
Individual level	Yes	Ref	Ref	Ref^	Ref^
	No	-0.01 (-0.18-0.16)	0.03 (-0.12-0.18)	0.01 (-0.15-0.17)	0.05 (-0.12-0.21)
School level	Q1 (highest with encouraging teacher)	Ref	Ref	Ref^	Ref
	Q2	-0.01 (-0.18-0.15)	-0.04 (-0.23-0.16)	0.04 (-0.16-0.24)	0.03 (-0.21-0.28)
	Q3	-0.11 (-0.28-0.05)	-0.11 (-0.31-0.09)	0.01 (-0.20-0.23)	0.07 (-0.19-0.33)
	Q4	-0.22 (-0.39--0.04)*	-0.17 (-0.37-0.03)	0.09 (-0.11-0.30)	0.17 (-0.08-0.42)

*Significantly different to reference category ($p<0.05$)

[1] Each of the school characteristics added individually to baseline model (adjusted for age, height SDS, pubertal status, and ethnicity).

^ Significant interaction between variable and ethnicity. P-values for the interaction terms are given below, full details in text.

Encouraging teacher (individual-level): Girls: BMI SDS p=0.0001, Waist SDS=0.0002

Encouraging teacher (school-level): Girls: BMI SDS p=0.049

Boys who said they disliked their teachers had lower BMI SD and Waist SD scores than those who said they liked their teachers. For girls it was whether they were in a school where a high proportion liked their teachers that was important rather than whether they personally liked their teacher; girls in schools with the lowest proportion saying they liked their teachers (Q4) had significantly higher BMI SD scores than those in schools where a high percentage liked their teachers (Q1). Those in Q4 also had higher Waist SD scores than those in Q1 although this was not statistically significant. This contextual variable was not associated with body size for boys.

Having an encouraging teacher was not significantly associated with either body size measure for boys or girls in the overall sample, however for girls there was a significant interaction with ethnicity for both BMI SDS and Waist SDS. White UK girls who did not think they had a teacher who encouraged them had BMI SD scores -0.33 (-0.65 to -0.01) lower, however the opposite was true for some other groups; the Other Africans who did not think they had a teacher who encouraged them had scores 0.84 (0.42 to 1.27) higher and similarly the Indian girls 0.54 (0.07 to 1.01) higher. Similarly, for Waist SDS the Other African girls who did not feel they had a teacher who encouraged them had SD scores 0.70 (0.26 to 1.15) higher than those who felt encouraged. For Indian girls the equivalent figures were 0.76 (0.26 to 1.25).

The aggregate form of this variable was significant for BMI SDS for boys; boys who were in schools where few pupils felt encouraged (Q4) had significantly lower BMI SD scores than those in Q1 and there was a trend across the quartiles. A similar pattern was observed for Waist SDS; a lower proportion of encouraging teachers being associated with a lower Waist SDS, however differences did not reach statistical significance. For girls, in the overall sample there was no significant relationship between school-level teacher encouragement and BMI SDS, but the interaction with ethnicity was significant. However on examining the results of the stratified models, the only significance was for Other Africans; Q2 v. Q1; 0.52 (0.06 to 0.98). There was therefore no strong indication of a contextual effect on BMI SDS for this variable. School-level teacher encouragement was not significant for Waist SDS for girls, although there was a trend across quartiles; less encouragement being associated with higher Waist SD score (therefore a trend in the opposite direction to that observed for the boys).

The aggregate variable of having an encouraging teacher had a relatively large effect on between school variance for BMI SDS; it decreased boys' by almost 80% and increased girls' by almost 50% (Table 4.38). However the small absolute amount of variance should again be emphasised. The impact of the aggregate form of the like teachers variable was considerably smaller; 14% for boys, 7% for girls. In contrast, for Waist SDS the aggregate like teachers variable explained more between school variability than the aggregate teacher encouragement variable, particularly for boys.

Table 4.38 Proportion of BMI SDS and Waist SDS variance explained by subjective opinion of teachers

		% variance explained by each model			
	Variance (Baseline)	Like teachers (individual)	Like teachers (aggregate)	Teacher who supports (individual)	Teacher who supports (aggregate)
BMI SDS					
Boys					
School	0.006	2.18	13.52	0.99	79.65
Individual	1.517	0.72	0.07	-0.06	0.00
Measurement	0.239	-0.04	-0.01	0.00	0.00
Total	1.762	0.62	0.10	-0.05	0.25
Girls					
School	0.015	-0.35	6.52	8.17	-48.48
Individual	1.317	-0.06	0.42	1.25	0.84
Measurement	0.186	0.00	0.01	0.00	0.01
Total	1.517	-0.06	0.43	1.16	0.27
Waist SDS					
Boys					
School	0.022	8.34	21.47	-1.72	6.45
Individual	1.055	1.04	-0.01	-0.03	-0.06
Measurement	0.479	-0.02	0.00	-0.01	0.00
Total	1.556	0.82	0.30	-0.04	0.05
Girls					
School	0.036	-2.17	9.18	5.47	-6.71
Individual	1.245	0.15	0.25	1.38	0.01
Measurement	0.504	-0.01	0.02	-0.01	0.00
Total	1.785	0.06	0.37	1.07	-0.13

4.3.6 Interactions with age

The analysis presented so far has assumed that any relationship between the school contextual variables and body size is constant across the age range. Interactions between wave of the study and each of the school characteristics were tested (with wave being a proxy for age, and hence length of exposure to the school environment). In Wave 1 of the study the pupils were aged 11-13yrs and were in their first or second year at their school; by the second wave they were aged 14-16yrs and had been exposed to their school environments for an additional 2 to 3 years. Consequently, the school environment might have had a greater effect at 14-16yrs due to the greater length of exposure. Alternatively, by the older ages the pupils may have been exposed to many additional influences and the relative importance of the school context may have lessened.

Several significant interactions between wave and the school characteristics were found; these are summarised in Table 4.39. Significant interactions which showed a consistent pattern in both genders, or for both measures within gender, are discussed further.

For girls, those in single-sex schools had higher BMI SD and Waist SD scores than those in mixed-sex schools at both ages, however the difference was greater at 11-13yrs (when it was significant for BMI SDS) than at 14-16yrs. In contrast, the difference in Waist SDS for girls in Catholic compared to non-denominational schools was greater at 14-16yrs than 11-13yrs.

Those in schools with the highest rates of unauthorised absence had higher Waist SD scores (boys and girls) and BMI SD scores (girls only) at both ages, with the difference being greater at 14-16yrs than 11-13yrs (although not reaching statistical significance for either gender). For boys, compared to those in the best academic performance schools, the others had higher BMI SD and Waist SD scores at both 11-13yrs and 14-16yrs, with the differences being greater at the older ages in all of the quartiles for BMI SDS. The pattern was more mixed for Waist SDS; the difference decreased for Q2 and Q3 but increased for Q4. None of the differences were statistically significant at either age for either body size measure.

Boys in schools rated above average or average/below average for guidance and support had significantly lower Waist SD scores than those in schools rated exceptionally high at 11-13yrs; the difference had decreased at 14-16yrs and was no longer statistically significant.

Compared to Nigerian/Ghanaians in schools with low Black African density (Q1), girls in Q2, Q3, and Q4 all had lower BMI SD and Waist SD scores at 11-13yrs but higher at 14-16yrs; none of the differences were statistically significant. Compared to Indian boys in schools with the lowest density of Indian pupils, those in the other quartiles had higher Waist SD scores at 11-13yrs (significantly so for those in Q2 and Q3), however differences decreased by 14-16yrs such that the higher scores of those in Q2 and Q3 were no longer significant, and those in Q4 actually had smaller waists than those in Q1. The pattern for Waist SDS was different for the Indian girls; those in Q2 and Q3 had smaller waists at both ages, although the difference was smaller at the older ages. Pakistani/Bangladeshi girls in the highest density Pakistani/Bangladeshi schools had higher Waist SD scores at both ages, with the difference being greater (although not statistically significant) at 14-16yrs than 11-13yrs.

Boys who disliked their teachers had significantly lower BMI SD scores than those who liked their teachers at both ages, with the difference being greater at 14-16yrs than 11-13yrs. Compared to boys in schools where a high proportion of pupils liked their teachers, those in Q2 and Q4 had significantly lower Waist SD scores at 11-13yrs but not 14-16yrs. Those in Q3 had lower scores at 11-13yrs and significantly higher at 14-16yrs.

Therefore several significant differences by age in the relationship between the school covariates and body size were evident, however there were few consistent patterns; some characteristics had a greater effect size at 11-13yrs than 14-16yrs and others vice versa.

Table 4.39 Summary of interactions between the school variables and wave

Empty cell if interaction was not significant (p>=0.05)

Filled cells contain p-value of interaction term (wave*variable)

First symbol indicates if effect of variable was positive (+) or negative (-) at Wave 1

Second symbol indicates if effect of variable was + or – at Wave 2.

* indicates that the variable was significantly associated with the outcome at that wave.

If direction of effect the same at both waves, a third symbol is given which indicates whether the effect size is larger (▲) or smaller (▼) at Wave 2 compared to Wave 1.

Therefore if the effect at Wave 1 was -0.3 (not significant) and at Wave 2 -0.6 (significant) then the code would be - -* ▲.

	Boys		Girls	
	BMI	Waist	BMI	Waist
School type & main characteristics				
School sex		P=0.006	P=0.01	P=0.006
Mixed (Ref)				
All boys		- +	/ /	/ /
All girls		/ /	+* + ▼	+ + ▼
School Religion		P=0.01		P<0.00005
Non-denominational (Ref)				
Church of England		- - ▼		+ -
Catholic		- +		+ + ▲
School roll (quartiles)		P=0.0001		P=0.0046
Q1 (smallest: Ref)				
Q2		- - ▲		+ +* ▲
Q3		+ -		+ + ▲
Q4		+ -		- +
Spending per pupil (tertiles)		P=0.0132		P=0.0001
T1 (Highest: Ref)				
T2		- +		+ +* ▲
T3		- - ▼		- +
Learning difficulties with statements (quartiles)		P<0.00005		P<0.00005
Q1 (Lowest proportion: Ref)		+ -		- - ▲
Q2		- +		+ -
Q3		+ + ▼		+ -
Q4				
Overall school effectiveness		P=0.0005		P=0.0001
Outstanding (Ref)				
Good		- +		-* - ▼
Satisfactory		- - ▼		- +
Inadequate		+ + ▼		- - ▼
Social environment				
English as 2nd language quartiles		P<0.00005		P=0.0002
Q1 (Lowest proportion: Ref)				
Q2		- -		- +
Q3		- +*		- +
Q4		- +		+ + ▼

	Nigerian/Ghanaian			P=0.0072	P=0.0013
	Q1 (Ref: Lowest proportion)				
	Q2			- +	- +
	Q3			- +	- +
	Q4			- +	- +
	Indian		P<0.00005		P<0.00005
	Q1 (Ref: Lowest proportion)				
	Q2		+* + ▼		- - ▼
	Q3		+* + ▼		- - ▼
	Q4		+ -		+ -
	Pakistani/Bangladeshi				P=0.0124
	Q1 (Ref: Lowest proportion)				
	Q2				+ -
	Q3				+ -
	Q4				+ + ▲
School SES					
	Unauthorised absence (quartiles)	P=0.0392	P=0.0002	P=0.01	P=0.0001
	Q1 (Lowest Absence: Ref)				
	Q2	- +	- +	- - ▼	- +
	Q3	- - ▼	- - ▼	- - ▼	- +
	Q4	- - ▼	+ + ▲	+ + ▲	+ + ▲
	Free School Meals (quartiles)		P<0.00005		P=0.0005
	Q1 (Lowest proportion: Ref)				
	Q2		- +		+ +* ▲
	Q3		-* +		- +
	Q4		- +		- +
	Academic Performance (quartiles)	P=0.0335	P=0.03		P=0.0004
	Q1 (Highest: Ref)				
	Q2	+ + ▲	+ + ▼		- +
	Q3	+ + ▲	+ + ▼		- +
	Q4	+ + ▲	+ + ▲		- +
Ethos					
	Overall personal development		P=0.0058		P<0.00005
	Exceptionally high (Ref)				
	Above average		- +		-* +
	Average/Below Average		- - ▲		- +
	Learners' enjoyment of education		P<0.00005		P<0.00005
	Exceptionally high (Ref)				
	Above average		- +		-* +
	Average/Below Average		- - ▼		- +
	Progress of those with learning difficulties				P=0.0185
	Exceptionally high (Ref)				
	Above average				
	Average/Below Average				- - ▼
	Exceptionally low				- +
					- - ▼
	Spiritual, moral, social & cultural development				P=0.0012
	Exceptionally high (Ref)				
	Above average				
	Average/Below Average				- - ▼
					- - ▼
	Pupils adopt healthy lifestyles		P<0.00005		P<0.00005
	Exceptionally high (Ref)				
	Above average		-* +		-* - ▼
	Average/Below Average		- +		- +
	Guidance and support		P<0.00005		
	Exceptionally high (Ref)				
	Above average		-* - ▼		
	Average/Below Average		-* - ▼		
Pupils' Opinions of teachers					
	Like teacher (individual level)	P=0.026			
	Dislike teachers (Ref:Like)	-* -* ▲			
	Like teachers (aggregate, quartiles)		P<0.00005		P=0.004
	Q1 (highest proportion liking: Ref)				
	Q2		-* +		- +
	Q3		- +*		- - ▼
	Q4		-* - ▼		+ + ▲
	Supportive teacher (aggregate, quartiles)		P<0.00005		P=0.0024
	Q1 (highest prop. supportive: Ref)				
	Q2		- +		+ -
	Q3		- +		+ + ▲
	Q4		- - ▼		+ + ▼

4.3.7 Key Points - School environment and body size

- Very little of the variation in BMI SDS and Waist SDS was due to differences between schools or neighbourhoods, however there was more variation between schools than between neighbourhoods.

- Much of the variance between schools in body size was explained by pupil ethnicity.

- Girls attending Catholic and single-sex schools had higher BMI SD scores, and to a lesser extent Waist SD scores, than girls in mixed, non-denominational schools.

- Greater own ethnic density in a school was associated with a decrease in both body size measures for White UK girls, Waist SDS for White UK boys, and both body size measures for Pakistani/Bangladeshi boys. There was a similar trend for Indian girls. In contrast, for Other African girls greater Black African density was associated with an increase in body size.

- Non-White UK density was not associated with body size; thus emphasising the importance of examining ethnic density effects on body size using ethic specific density measures rather than an aggregate measure.

- There were few significant associations between the measures of school SES and body size.

- The ethos of a school was generally not associated with body size, however there were associations between pupils' subjective opinions of teachers and body size.

4.4 Choice of variables for inclusion in final models

In this chapter the univariate association between each of the school characteristics and body size has been tested (after adjustment for age, pubertal status, and height). In the following chapters, neighbourhood (Chapter 5) and individual/family characteristics (Chapter 6) will be examined in a similar way. In the final findings chapter (Chapter 7), a selection of school, neighbourhood and individual/family variables are included in final, fully-adjusted models. Variables were selected for inclusion in these final models if they had shown an association with body size in the univariate analysis or if there were strong theoretical reasons to include them. However in multilevel models the number of upper-level variables that can be included in the model is limited by the number of clusters at that level. As boys were clustered in 40 schools and the girls in 41 it was estimated that it would be possible to include a maximum of approximately 4 school-level variables.

School ethnic density was selected because of the significant association found between body size and own ethnic density for some groups (the 6 individual own ethnic density variables were recoded into a single variable for inclusion in the final models, more details are provided in the Final Model chapter). Although little association was found between school SES and body size, it was considered important to include school SES in the final models as we wanted to determine the relative importance of school, neighbourhood, and family level SES measures, and also the effect of adjustment for both ethnic density and deprivation. Two measures of school SES (unauthorised absence and academic performance) were therefore selected. Finally, as both school sex and school religion were significantly associated with BMI SDS for girls, it was decided to also include these school characteristics in the final models where statistically possible.

5 Neighbourhood contexts and their association with body size

This chapter focuses on the pupils' neighbourhood environments; both their residential neighbourhoods and the neighbourhoods of their schools. The neighbourhood characteristics examined were: ethnic density; deprivation and crime; and land use. The first section of this chapter gives overall and ethnic patterns in these neighbourhood characteristics, and also considers differences by age and sex. The second section examines whether any of the neighbourhood characteristics were associated with body size.

The aims of this chapter were to:

1. Characterise the neighbourhoods in which the DASH pupils lived and attended school, and identify ethnic and gender differences in these neighbourhoods.

2. Determine whether any of the neighbourhood characteristics were associated with body size, and whether these associations differed by ethnicity or age.

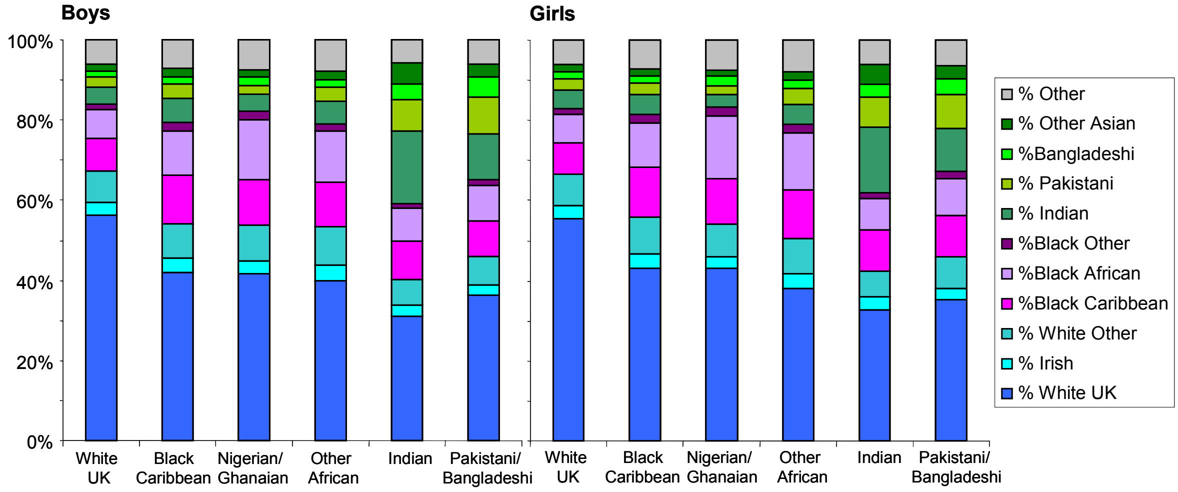
3. Determine whether the neighbourhood characteristics explained any of the variance in body size at the measurement, individual or school level.

5.1 Residential Neighbourhoods

5.1.1 Ethnic Density

The ethnic composition of the neighbourhoods was examined by sex and ethnicity (Figure 5.1); on average DASH pupils in every ethnic group lived in ethnically diverse neighbourhoods. The largest ethnic group in the neighbourhoods of every DASH ethnic group was White UK, although it was only in the neighbourhoods of the White UK pupils that White UK people on average comprised more than half of the population. The Indian pupils lived in neighbourhoods with the smallest proportion of White UK residents (just under a third). In the Indian pupils' neighbourhoods on average almost a third of the population was of South Asian origin (Indian, Pakistani or Bangladeshi). South Asians also made up a sizeable proportion (almost 25%) of the Pakistani/Bangladeshi pupils' neighbourhoods.

Figure 5.1 Residential neighbourhood ethnic density by ethnicity and sex, 11-13yrs



Ethnic-specific ethnic density quartiles were derived to allow the examination of the association between own ethnic density and body size. The cut-offs for each quartile varied considerably between the different ethnic densities due to the very different distributions of the ethnic density variables (Table 5.1). For example, neighbourhoods in Q1 of the White UK ethnic density variable had a mean White UK density ranging from 11% to 42% for girls. Q1 of each of the other neighbourhood ethnic density variables had much lower proportions (all had maximum values less than 10%). Similarly, proportions in Q4 were much higher for the White UK group (ranging from approximately 70% to 95%) than the others. The ethnic density proportions for Q4 were lowest for the Black

Caribbeans (16% to 29%). This means that for many of the minority ethnic groups, the ethnic density levels in Q4 are lower than the ethnic density levels in Q1 for the White UK.

Table 5.1 Residential neighbourhood ethnic specific ethnic density quartiles

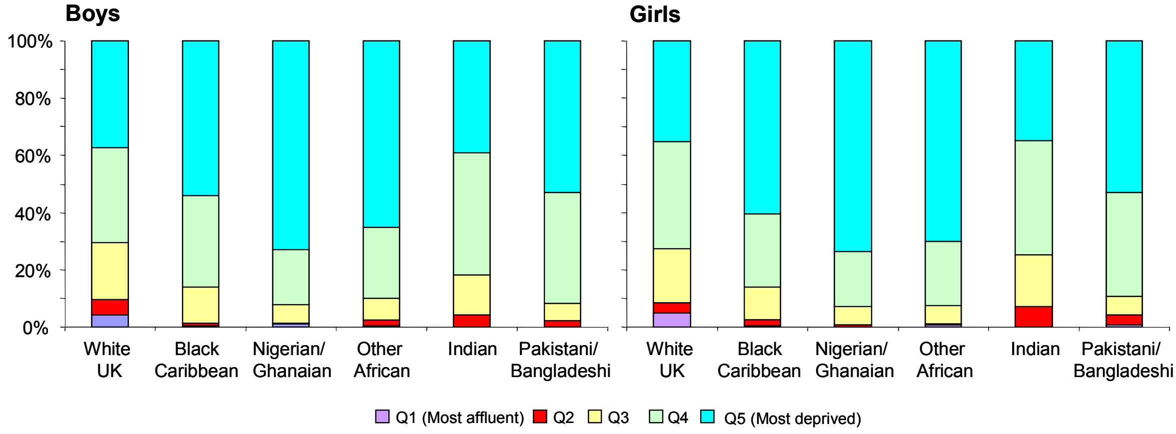
		Boys		Girls	
Own ethnic density		Mean	Range	Mean	Range
White UK	Q1 (lowest)	33.5	13.1 - 42.0	32.1	11.1-41.8
	Q2	49.7	42.0 - 55.9	49.4	41.8-55.2
	Q3	62.5	56.3-68.73	61.7	55.3-70.9
	Q4 (highest)	79.6	68.9-94.8	81.8	71.0-94.8
Black Caribbean	Q1 (lowest)	5.5	0.4-8.0	5.4	0.4-8.0
	Q2	10.1	8.0-11.9	10.1	8.0-11.8
	Q3	13.8	11.9-15.8	13.8	11.8-16.1
	Q4 (highest)	19.6	15.8-29.4	19.4	16.1-29.4
Nigerian/Ghanaian	Q1 (lowest)	4.7	0.3-7.6	4.7	0.3-8.1
	Q2	10.6	7.7-13.6	11.1	8.1-14.4
	Q3	16.8	13.7-21.2	17.8	14.7-21.2
	Q4 (highest)	26.5	21.3-43.9	27.3	21.3-43.9
Other African	Q1 (lowest)	4.1	0.4-6.5	5.1	0-7.9
	Q2	8.2	6.5-11.0	9.9	7.9-12.3
	Q3	13.7	11.1-16.7	16.0	12.5-18.8
	Q4 (highest)	23.8	16.7-36.4	25.0	18.8-40.8
Indian	Q1 (lowest)	3.9	0.3-6.3	3.3	0.47-5.5
	Q2	11.5	6.4-17.1	9.3	5.6-13.8
	Q3	23.9	17.3-27.9	21.1	14.3-26.1
	Q4 (highest)	33.1	28.0-41.4	32.0	26.6-52.4
Pakistani/Bangladeshi	Q1 (lowest)	2.8	0.2-5.2	2.4	0.3-4.5
	Q2	8.1	5.2-11.2	7.2	4.6-9.8
	Q3	16.4	11.2-22.5	14.6	9.8-18.1
	Q4 (highest)	31.1	22.6-41.7	26.6	18.2-41.7

A comparison of these residential ethnic density quartiles to the school ethnic density quartiles (Table 4.6) shows that for each of the ethnic minority groups, there was generally more ethnic clustering in schools than in neighbourhoods. For example, as was shown in Chapter 4, the highest Black Caribbean density in the schools of the Black Caribbean boys was 39%, compared to a highest Black Caribbean neighbourhood density of 29%. There were two exceptions; the Indian girls' highest school density was 44% but the highest neighbourhood density 52%, and the White UK pupils had higher White UK density in their neighbourhoods than in their schools. The residential ethnic density quartiles were very similar for both boys and girls. This contrasts with the gender differences observed for school ethnic density, particularly for the Nigerian/Ghanaians.

5.1.2 Deprivation and Crime

Quintiles of the Index of Multiple Deprivation (IMD) were used to measure neighbourhood deprivation (the most affluent neighbourhoods in England were in Q1, and the most deprived in Q5). The majority of the DASH pupils in every ethnic group lived in a relatively deprived neighbourhood (Q4 or Q5); ranging from just over 70% of the White UK pupils to ≥90% of the Nigerian/Ghanaians, Other Africans and Pakistani/Bangladeshis (Table 5.2; Figure 5.2). The White UK and Indian boys and girls were least likely to live in Q5 and most likely to live in Q1, 2 or 3.

Figure 5.2: Neighbourhood Deprivation Quartiles by sex and ethnicity (Wave 1)



Many of the pupils lived in high crime areas; for most groups around 40% or more lived in Q5 (highest crime quintile) (Table 5.2). More than 80% of the Black Caribbean, Nigerian/Ghanaian, Other African and Pakistani/Bangladeshis lived in a neighbourhood in Q4 or Q5. The Nigerian/Ghanaian boys and girls at both ages, and the Other African boys at 11-13yrs, were significantly more likely to live in Q5 than their White UK peers. Proportions living in Q1 were very small, being highest for the White UK pupils (at around 3% or less). There were no significant differences in neighbourhood crime by age or gender.

Table 5.2 Residential Neighbourhood Deprivation and crime

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys							
N		490	389	207	209	237	305
Deprivation							
Q1 (Least deprived) (%)	11-13	4.3 (2.5-6.1)	0.3 (0.0-0.8)*	1.0 (0.0-2.3)*	0.5 (0.0-1.4)*	0*	0*
	14-16	3.9 (2.2-5.6)	0.3 (0.0-0.8)*	1.0 (0.0-2.3)	1.9 (0.0-3.8)	0.8 (0.0-2.0)*	0*
Q5 (Most deprived) (%)	11-13	37.3 (33.0-41.6)	54.2 (49.3-59.2)*	72.9 (66.8-79.0)*	65.1 (58.6-71.6)*	39.2 (33.0-45.5)	53.1 (47.5-58.7)*
	14-16	39.2 (34.8-43.5)	53.7 (48.8-58.7)*	73.4 (67.4-79.5)*	65.6 (59.1-72.0)*	43.0 (36.7-49.4)	60.7 (55.1-66.2)*
Crime							
Q1 (Lowest crime) (%)	11-13	1.6 (0.5-2.8)	0*	0*	0.5 (0.0-1.4)	1.7 (0.0-3.3)	0.3 (0.0-1.0)
	14-16	2.7 (1.2-4.1)	0*	2.9 (0.6 -5.2)^	1.0 (0.0-2.3)	0.4 (0.0-1.3)	0.3 (0.0-1.0)
Q5 (Highest crime) (%)	11-13	41.2 (36.9-45.6)	47.0 (42.1-52.0)	59.4 (52.7-66.2)*	54.5 (47.7-61.4)*	46.0 (39.6-52.4)	46.6(40.9-52.4)
	14-16	39.6 (35.2-43.9)	48.8 (43.9-53.8)	53.6 (46.8-60.5)*	48.8 (42.0-55.6)	36.7 (30.5-42.9)	40.3 (34.8-45.9)
Girls							
N		380	389	297	177	181	140
Deprivation							
Q1 (Least deprived) (%)	11-13	5.0 (2.8-7.2)	0.5 (0.0-1.2)*	0.8 (0.0-1.6)*	0.6 (0.0-1.7)*	0*	0.7 (0.0-2.1)*
	14-16	4.5 (2.4-6.6)	0.3 (0.0-0.8)*	0.7 (0.0-1.6)*	0.6 (0.0-1.7)*	1.1 (0.0-2.6)	0.7 (0.0-2.1)*
Q5 (Most deprived) (%)	11-13	35.3 (30.4-40.1)	60.7 (55.8-65.5)*	73.7 (68.7-78.8)*	70.1 (63.2-76.9)*	34.8 (27.8-41.8)	52.9 (44.5-61.2)*
	14-16	38.4 (33.5-43.3)	58.9 (54.0-63.8)*	68.7 (63.4-74.0)*	68.4 (61.4-75.3)*	35.9 (28.9-43.0)	65.7 (57.8-73.7)*
Crime							
Q1 (Lowest crime) (%)	11-13	2.4 (0.8-3.9)	0.3 (0.0-0.8)*	1.3 (0.0-2.7)	1.1 (0.0-2.7)	0.6 (0.0-1.6)	0.7 (0.0-2.1)
	14-16	3.2 (1.4-4.9)	0*	1.3 (0.0-2.7)	0.6 (0.0-1.7)	0*	0.7 (0.0-2.1)
Q5 (Highest crime) (%)	11-13	41.6 (36.6-46.6)	49.4 (44.4-54.3)	53.9 (48.2-59.6)*	47.5 (40.0-54.9)	38.1 (31.0-45.3)	50.0 (41.6-58.4)
	14-16	35.3 (30.4-40.1)	43.2 (38.2-48.1)	46.5 (40.8-52.2)*	46.3 (38.9-53.7)	32.6 (25.7-39.5)	43.6 (35.3-51.9)

*Significantly different to White UK (non-overlapping confidence intervals)

^Significantly different, within ethnic group, at 14-16yrs compared to 11-13yrs

5.1.3 Land Use

Five categories of land use were examined: domestic buildings, non-domestic buildings, roads, green space, and domestic (private) gardens. Quartiles of each of these measures were calculated (Q1 lowest proportion of land use, Q4 highest proportion of land use). The cut-offs for the quartile variables differed by land use (Table 5.3 gives summary of 2001 quartiles; figures for 2005 were very similar hence are not shown). Of the land use types, green space showed the most variability between neighbourhoods, ranging from 0% to over 90%. There was little difference between the boys and girls in the quartiles values for any of the land use types. Gender, ethnic and age differences in residential land use are summarised in Table 5.4 (Boys) and Table 5.5 (Girls).

Table 5.3 Summary of residential neighbourhood land use quartiles (2001)

		Boys Mean (%)	Range (%)	Girls Mean (%)	Range (%)
Domestic buildings	Q1 (lowest)	7.1	0.5-10.6	7.1	0.5-10.6
	Q2	12.9	10.3-15.3	12.6	10.6-14.5
	Q3	18.4	15.3-21.6	17.3	14.5-19.7
	Q4 (highest)	25.6	21.7-36.8	24.4	19.7-36.8
Non-domestic buildings	Q1 (lowest)	1.3	0-2.4	1.2	0-2.3
	Q2	3.9	2.4-5.6	3.8	2.3-5.4
	Q3	7.6	5.6-9.8	7.7	5.4-10.2
	Q4 (highest)	15.3	9.8-47.6	15.6	10.2-34.6
Roads	Q1 (lowest)	11.9	1.6-15.5	11.8	2.1-15.5
	Q2	18.0	15.5-20.1	17.9	15.5-20.0
	Q3	21.8	20.1-23.6	21.8	20-23.3
	Q4 (highest)	26.5	23.6-37.9	26.5	23.4-44.6
Green Space	Q1 (lowest)	2.4	0-5.4	3.1	0-6.4
	Q2	8.5	5.4-12.1	10.2	6.5-13.7
	Q3	17.7	12.2-25.1	18.7	13.8-25.5
	Q4 (highest)	40.8	25.1-92.6	40.3	25.5-90.5
Gardens	Q1 (lowest)	13.8	2.0-19.8	12.7	4.1-17.1
	Q2	24.4	20.1-27.4	23.0	17.3-27.1
	Q3	30.6	27.5-33.6	30.5	27.2-33.6
	Q4 (highest)	38.4	33.9-56.5	38.2	33.8-56.5

Table 5.4 Boys: Residential Neighbourhood Land Use

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N		490	389	207	209	237	305
Domestic Buildings							
Q1 (Least)	11-13	31.5 (27.3-35.6)	22.1(18.0-26.2)*	28.5 (22.3-34.7)	32.5 (26.1-38.9)	15.2 (10.6-19.8)*	18.7 (14.3-23.1)*
	14-16	32.4 (28.3-36.6)	21.6 (17.5-25.7)*	30.4 (24.1-36.8)	33.0 (26.6-39.4)	13.9 (9.5 – 18.4)*	17.0 (12.8-21.3)*
Q4 (Most)	11-13	16.3 (13.0-19.6)	26.0 (21.6-30.3)*	16.4 (11.3-21.5)	23.9 (18.1-29.8)	32.9 (26.9-38.9)*	38.0 (32.6-43.5)*
	14-16	16.9 (13.6-20.3)	24.9 (20.6-29.3)*	16.9 (11.8-22.1)	23.0 (17.2-28.7)	31.2 (25.3-37.2)*	39.0 (33.5-44.5)*
Non Domestic Buildings							
Q1 (Least)	11-13	33.5 (29.3-37.7)	21.3 (17.2-25.4)*	14.0 (9.2-18.8)*	22.5 (16.8-28.2)*	28.3 (22.5-34.0)	23.0 (18.2-27.7)*
	14-16	30.8 (26.7-34.9)	22.9 (18.7-27.1)	14.5 (9.7-19.3)*	27.3 (21.2-33.4)	29.1 (23.3-34.9)	22.3 (17.6-27.0)
Q4 (Most)	11-13	18.0 (14.5-21.4)	25.7 (21.3-30.1)	44.4 (37.6-51.3)*	34.9 (28.4-41.4)*	16.9 (12.1-21.7)	19.7 (15.2-24.2)
	14-16	19.6 (16.0-23.1)	24.9 (20.6-29.3)	43.0 (36.2-49.8)*	34.0 (27.5-40.4)*	16.5 (11.7-21.2)	21.6 (17.0-26.3)
Roads							
Q1 (Least)	11-13	34.7 (30.5-38.9)	22.4 (18.2-26.5)*	18.4 (13.0-23.7)*	23.9 (18.1-29.8)*	23.6 (18.2-29.1)*	20.0 (15.5-24.5)*
	14-16	35.9 (31.7-40.2)	22.6 (18.4-26.8)*	17.4 (12.2-22.6)*	27.3 (21.2-33.4)*	21.9 (16.6-27.2)*	16.7(12.5-20.9)*
Q4 (Most)	11-13	16.7 (13.4-20.1)	25.4 (21.1-29.8)*	32.4 (25.9-38.8)	26.3 (20.3-32.3)*	24.9 (19.3-30.4)	31.1 (25.9-36.4)*
	14-16	17.1 (13.8-20.5)	26.0 (21.6-30.3)*	30.9 (24.6-37.3)*	30.6 (24.3-36.9)*	24.5 (19.0-30.0)	28.8 (23.7-34.0)*
Green Space							
Q1 (Least)	11-13	17.3 (14.0-20.7)	22.9 (18.7-27.1)	20.8 (15.2-26.3)	22.0 (16.3-27.7)	37.6 (31.3-43.8)*	35.4 (30.0-40.8)*
	14-16	16.9 (13.6-20.3)	23.4 (19.2-27.6)	20.8 (15.2-26.3)	20.1 (14.6-25.6)	35.4 (29.3-41.6)*	38.4 (32.9-43.8)*
Q4 (Most)	11-13	33.1 (28.9-37.2)	23.7 (19.4-27.9)*	25.1 (19.2-31.1)	25.4 (19.4-31.3)	17.7 (12.8-22.6)*	19.0 (14.6-23.4)*
	14-16	34.9 (30.7-39.1)	21.6 (17.5-25.7)*	20.8 (15.2-26.3)*	28.7 (22.5-34.9)	18.1 (13.2-23.1)*	19.0 (14.6-23.4)*
Gardens							
Q1 (Least)	11-13	24.1 (20.3-27.9)	28.0 (23.5-32.5)	48.3 (41.4-55.2)*	33.0 (26.6-39.4)	6.8 (3.5-10.0)*	18.7 (14.3 -23.1)
	14-16	24.1 (20.3-27.9)	26.0 (21.6-30.3)	50.2 (43.4-57.1)*	35.9 (29.3-42.4)*	5.5 (2.6-8.4)*	18.4 (14.0-22.7)
Q4 (Most)	11-13	25.9 (22.0-29.8)	22.4 (18.2-26.5)	11.1 (6.8-15.4)*	20.1 (14.6-25.6)	35.9 (29.7-42.0)	30.5 (25.3-35.7)
	14-16	26.7 (22.8-30.7)	25.4 (21.1-29.8)	13.0 (8.4 -17.7)*	16.3 (11.2-21.3)*	35.9(29.7-42.0)	27.2 (22.2-32.2)

*Significantly different to White UK (non-overlapping confidence intervals)

^Significantly different, within ethnic group, at 14-16yrs compared to 11-13yrs

Table 5.5 Girls: Residential Neighbourhood Land Use

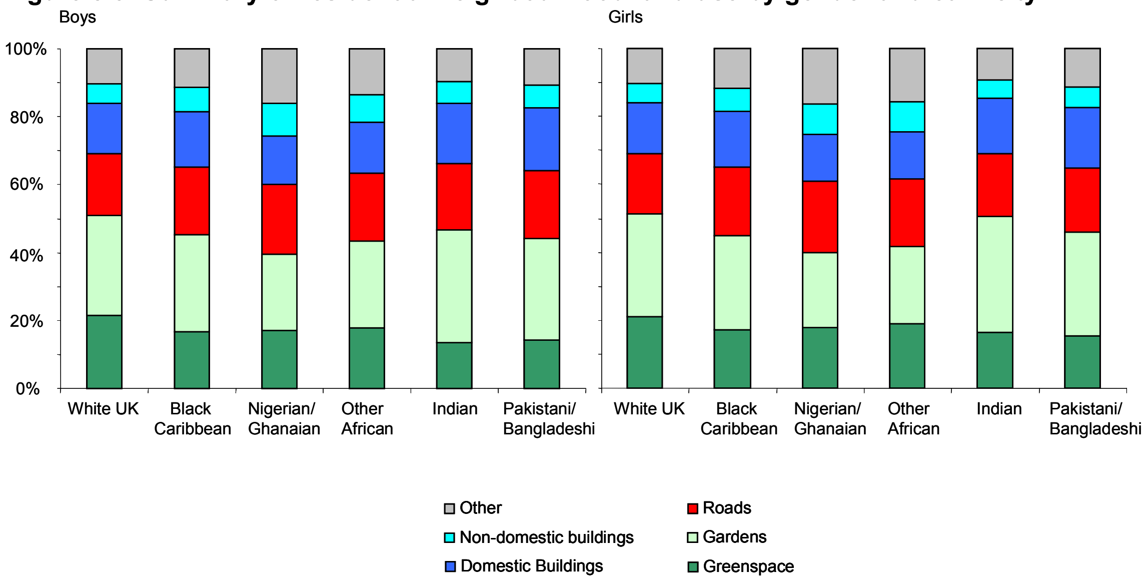
	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N		380	389	297	177	181	140
Domestic Buildings							
Q1 (Least)	11-13	30.3 (25.6-34.9)	18.0 (14.2-21.8)*	30.3 (25.0-35.6)	34.5 (27.4-41.5)	16.0 (10.6-21.4)*	19.3 (12.7-25.9)
	14-16	30.5 (25.9-35.2)	18.3 (14.4-22.1)*	31.6 (26.3-37.0)	31.1 (24.2-38.0)	15.5 (10.2-20.8)*	19.3 (12.7-25.9)
Q4 (Most)	11-13	23.2 (18.9-27.4)	29.0 (24.5-33.6)	17.8 (13.5-22.2)	18.6 (12.9-24.4)	26.5 (20.0-33.0)	37.9 (29.7-46.0)*
	14-16	22.1 (17.9-26.3)	28.0 (23.5-32.5)	16.8 (12.6-21.1)	22.6 (16.4-28.8)	26.5 (20.0-33.0)	42.1 (33.9-50.4)*
Non Domestic Buildings							
Q1 (Least)	11-13	35.5 (30.7-40.4)	23.7 (19.4-27.9)*	12.8 (9.0-16.6)*	14.1 (8.9-19.3)*	33.7 (26.7-40.7)	28.6 (21.0-36.1)
	14-16	34.2 (29.4-39.0)	23.1 (18.9-27.3)*	14.5 (10.5-18.5)*	16.9 (11.4-22.5)*	34.3 (27.3-41.2)	25.7 (18.4-33.0)
Q4 (Most)	11-13	17.9 (14.0-21.8)	22.9 (18.7-27.1)	38.7 (33.1-44.3)*	35.6 (28.5-42.7)*	14.9 (9.7-20.2)	17.1 (10.8-23.5)
	14-16	19.5 (15.5-23.5)	25.7 (21.3-30.1)	35.7 (30.2-41.2)*	31.1 (24.2-38.0)*	14.9 (9.7-20.2)	20.0 (13.3-26.7)
Roads							
Q1 (Least)	11-13	36.1 (31.2-40.9)	17.5 (13.7-21.3)*	17.8 (13.5-22.2)*	24.9 (18.4-31.3)	30.4 (23.6-37.2)	24.3 (17.1-31.5)
	14-16	36.1 (31.2-40.9)	18.8 (14.9-22.7)*	20.2 (15.6-24.8)*	22.6 (16.4-28.8)*	29.3 (22.6-36.0)	20.0 (13.3-26.7)*
Q4 (Most)	11-13	16.3 (12.6-20.2)	30.3 (25.7-34.9)*	33.0 (27.6-38.4)*	26.0 (19.5-32.5)	18.2 (12.6-23.9)	24.3 (17.1-31.5)
	14-16	15.8 (12.1-19.5)	30.3 (25.7-34.9)*	30.6 (25.4-35.9)*	26.6 (20.0-33.1)*	21.0 (15.0-27.0)	24.3 (17.1-31.5)
Green Space							
Q1 (Least)	11-13	21.8 (17.7-26.0)	27.2 (22.8-31.7)	20.5 (15.9-25.2)	14.7 (9.4-20.0)	35.4 (28.3-42.4)*	36.4 (28.4-44.5)*
	14-16	20.5 (16.4-24.6)	28.0 (23.5-32.5)	19.9 (15.3-24.4)	19.2 (13.3-25.1)	34.8 (27.8-41.8)*	34.3 (26.3-42.2)*
Q4 (Most)	11-13	31.1 (26.4-35.7)	21.6 (17.5-25.7)*	23.6 (18.7-28.4)	28.2 (21.6-34.9)	21.5 (15.5-27.6)	21.4 (14.5-28.3)
	14-16	30.3 (25.6-34.9)	21.9 (17.7-26.0)	25.3 (20.3-30.2)	28.8 (22.1-35.6)	20.4 (14.5-26.4)	20.0 (13.3-26.7)
Gardens							
Q1 (Least)	11-13	22.6 (18.4-26.9)	22.4 (18.2-26.5)	40.7 (35.1-46.4)*	39.0 (31.7-46.2)*	8.3 (4.2-12.3)*	12.9 (7.2-18.5)
	14-16	23.2 (18.9-27.4)	21.3 (17.2-25.4)	39.7 (34.1-45.3)*	36.7 (29.6-43.9)*	8.8 (4.7-13.0)*	15.0 (9.0-21.0)
Q4 (Most)	11-13	32.9 (28.1-37.6)	22.9 (18.7-27.1)*	13.1 (9.3-17.0)*	17.5 (11.9-23.2)*	34.8 (27.8-41.8)	30.0 (22.3-37.7)
	14-16	31.3 (26.6-36.0)	21.9 (17.7-26.0)*	14.5 (10.5-18.5)*	19.2 (13.3-25.1)*	35.4 (28.3-42.4)	26.4 (19.0-33.8)

*Significantly different to White UK (non-overlapping confidence intervals)

^Significantly different, within ethnic group, at 14-16yrs compared to 11-13yrs

How the different land uses come together to form a neighbourhood was also examined by ethnicity (Figure 5.3). The 'Other' category includes rail, water, paths, and unclassified. Across the ethnic groups, the overall composition of the neighbourhood looks similar; perhaps not surprising given that all of the neighbourhoods in which the pupils lived were in London, and hence all were relatively urban areas, and all were within commuting distance of one of the DASH schools. This obviously impacts on the variability that could be expected. However, closer inspection does reveal differences between the ethnic groups.

Figure 5.3: Summary of residential neighbourhood land use by gender and ethnicity



On average about 50% of the land in the White UK and Indian pupils' neighbourhoods was either gardens or green space; a higher proportion than any of the other groups. The Indians and Pakistani/Bangladeshis were significantly less likely than the White UK to live in an area with a high proportion of green space but many lived in areas with a high proportion of private gardens. The Nigerian/Ghanaian pupils were the most likely to live in an area with a low proportion of gardens; 50% of the Nigerian/Ghanaian boys and 40% of the Nigerian/Ghanaian girls lived in Q1, as did over a third of the Other African pupils. The proportion of gardens is likely to reflect both the level of domestic buildings in an area and the types of buildings. For example, an area with a high concentration of houses will have a higher proportion of land which is garden than an area with few domestic buildings or an area where most of the domestic buildings are flats.

Buildings (domestic and non-domestic) comprised around a fifth of the land use of the White UK neighbourhoods. This was the lowest proportion of any of the ethnic groups. In contrast, buildings made up approximately a quarter of the land type in the Pakistani/Bangladeshis' neighbourhoods. The Black Caribbean, Indian and Pakistani/Bangladeshi pupils were the most likely to live in areas with a high proportion of domestic buildings, and the Nigerian/Ghanaians and Other Africans to live in areas with a high proportion of non-domestic buildings. The White UK and Indian pupils were the least likely to live in areas with high proportions of non-domestic buildings.

The White UK pupils were the most likely to live in areas with a low proportion of roads, and the least likely to live in areas with a high proportion of roads. The Black Caribbeans, Nigerian/Ghanaians and Other African boys and girls, and Pakistani/Bangladeshis boys, were significantly more likely to be in Q4 (highest proportion of roads) than their White UK peers. For example, at 14-16yrs approximately 17% of the White UK pupils lived in an area in Q4 compared to over 30% of the Nigerian/Ghanaian pupils, Black Caribbean girls and Other African boys.

The land use types were ranked by ethnic group (Table 5.6). Gardens made up the largest proportion of land in every group. Green space, roads, and domestic buildings constituted the next three largest land uses however there were ethnic differences in their ranking. Green space was second for the White UK group, but roads for every other group. The third largest land use was roads for White UK, domestic buildings for the Indians and Pakistani/Bangladeshis and green space for the others. Overall, it appears the White UK pupils were living in relatively suburban, residential and less built-up areas compared to the other ethnic groups. The Indians and Pakistani/Bangladeshis tended to be living in more built-up areas with more buildings than green space. However, although these rankings differ by ethnic group, the actual percentages were often very similar as the previous figures have shown. Therefore, it is perhaps questionable whether there were enough ethnic differences in the land use of the different neighbourhoods to detect any potential impact on body size.

Table 5.6: Land Use rankings by ethnic group

	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
First[1]	Gardens	Gardens	Gardens	Gardens	Gardens	Gardens
Second	Greenspace	Roads	Roads	Roads	Roads	Roads
Third	Roads	Greenspace	Greenspace	Greenspace	Dom. buildings	Dom. buildings
Fourth	Dom. buildings	Dom. buildings	Dom. buildings	Dom. buildings	Greenspace	Greenspace

[1] Rankings based on proportions. Same results for boys and girls.

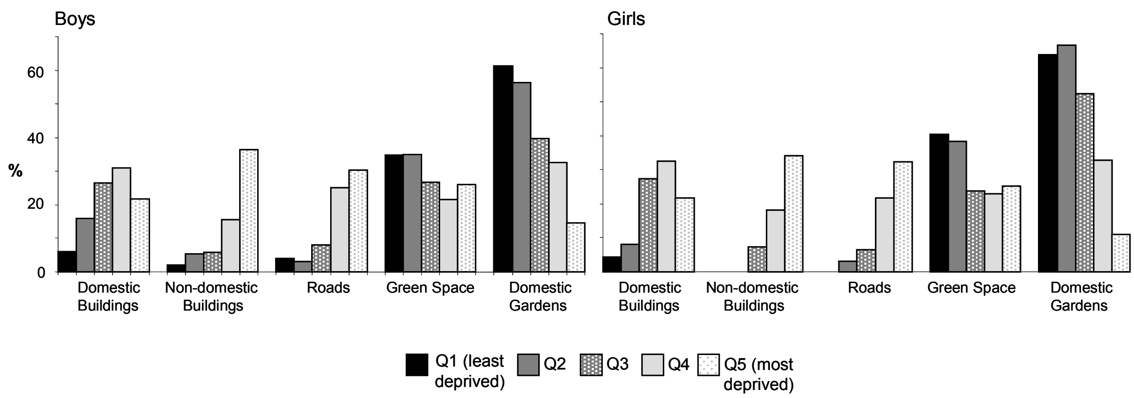
5.1.4 Associations between ethnic density, deprivation, and land use

A series of cross-tabulations were undertaken to determine how the deprivation, ethnic density and land-use variables related to one another. The cross-tabulations involving an ethnic density variable were ethnic-specific (i.e. ethnic density refers to own ethnic density). Results presented are for neighbourhoods at 11-13yrs (results at 14-16yrs were very similar).

Neighbourhood land use differed by deprivation level (Figure 5.4). Greater deprivation was strongly associated with a greater proportion of non-domestic buildings and roads and a lower proportion of gardens. The association between green space and deprivation was less strong than that observed for the other land uses but more affluent areas had higher proportions of green space.

Figure 5.4 Land Use by Neighbourhood Deprivation

(figure shows % in Q4 of each land use type by deprivation quintile)



Neighbourhood deprivation and ethnic density were strongly associated (Figure 5.5). For White UK pupils, the higher the density of White UK in their neighbourhoods, the less deprived their neighbourhoods tended to be. For the Black Caribbeans, Nigerian/Ghanaians, Other Africans, and Pakistani/Bangladeshis the opposite pattern was observed; higher own ethnic density was associated with greater neighbourhood deprivation. There was a gender difference for the Indians; for the girls the pattern mirrored that observed for the White UK group, but there was not a clear pattern for the boys. The association between crime and ethnic density followed a similar pattern to that observed for deprivation, but the differences between the ethnic density quartiles were not as large (Figure 5.6). Higher White UK and Indian density was generally associated with lower crime, and greater density of each of the other groups with higher crime.

The relationship between ethnic density and land use also differed by ethnic group. With regards to building type, higher own ethnic density was associated with a lower proportion of domestic buildings and a higher proportion of non-domestic buildings for Nigerian/Ghanaians and Other Africans. In contrast, for the White UK, Indians, and Pakistani/Bangladeshis, higher own ethnic density was associated with a lower proportion of non-domestic buildings. A lower proportion of roads in the neighbourhood was associated with greater own ethnic density for the White UK and the Indians but the opposite was true for the Pakistani/Bangladeshis, Black Caribbeans, Nigerian/Ghanaians and Other Africans.

Greater own ethnic density was associated with a greater proportion of green space for the White UK and Other Africans, but with less green space for the Pakistani/Bangladeshis, Black Caribbeans and Indian boys (Figure 5.7). Greater own ethnic density was associated with more gardens for the White UK pupils (Figure 5.8). A similar pattern was observed for the Indians and Pakistani/Bangladeshis, particularly for the boys in these ethnic groups. For the Nigerian/Ghanaians and Other Africans greater Black African density was associated with lower proportions of gardens. In both of these ethnic groups none of the boys, and less than 3% of the girls, in high Black African density neighbourhoods (Q4) lived in an area with the highest proportion of gardens (Q4)

Figure 5.5 Residential neighbourhood deprivation and own ethnic density

Figure shows % living in most deprived neighbourhoods (Q5) by own ethnic density quartiles

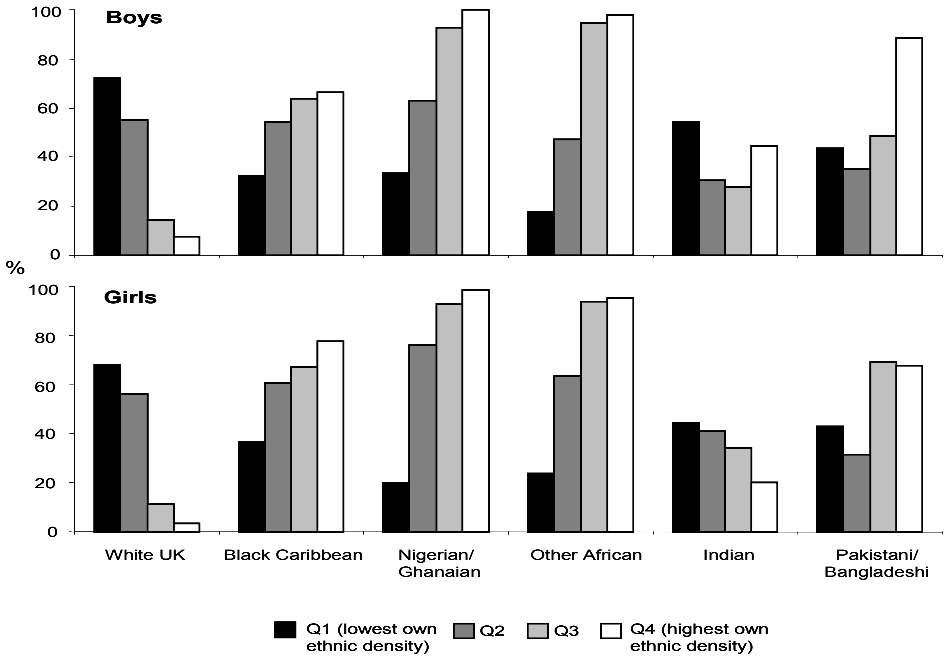


Figure 5.6 Residential neighbourhood crime and own ethnic density

Figure shows % living in highest crime neighbourhoods (Q5) by own ethnic density quartiles

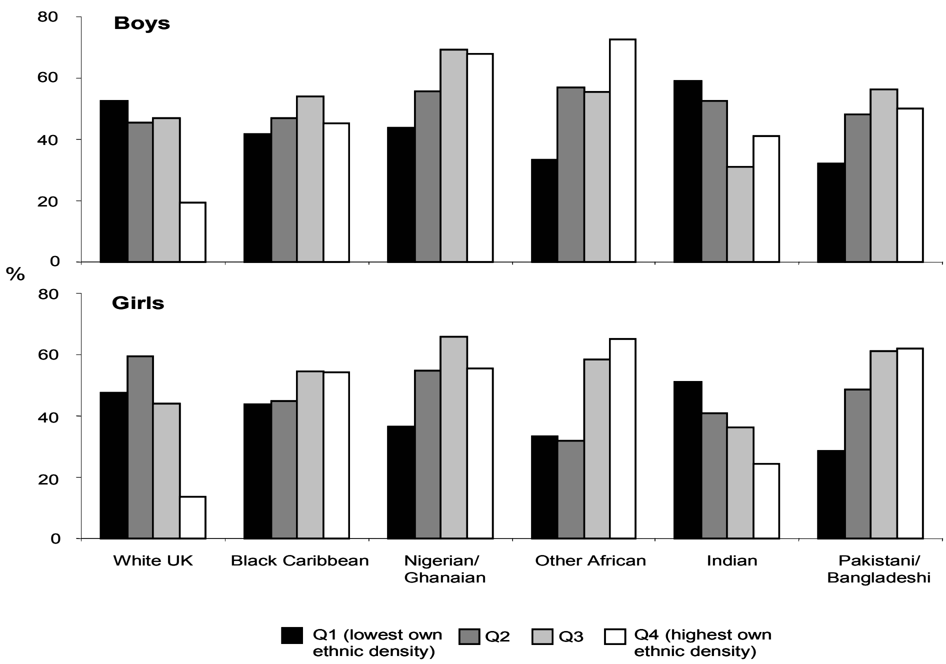


Figure 5.7 Residential neighbourhood green space and own ethnic density

Figure shows % living in neighbourhoods with most green space (Q4) by own ethnic density quartiles

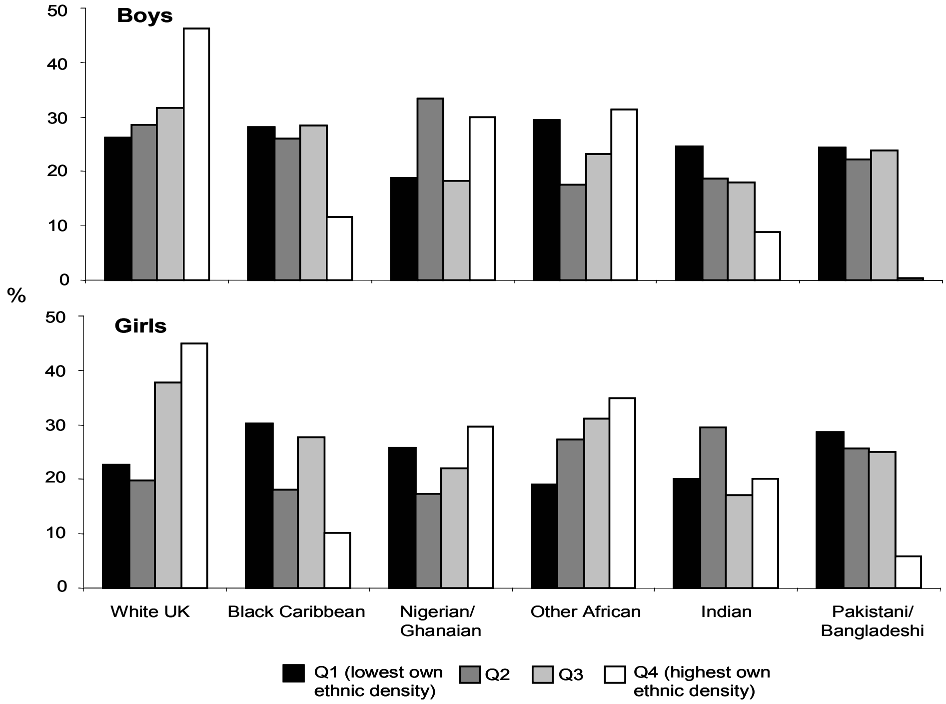
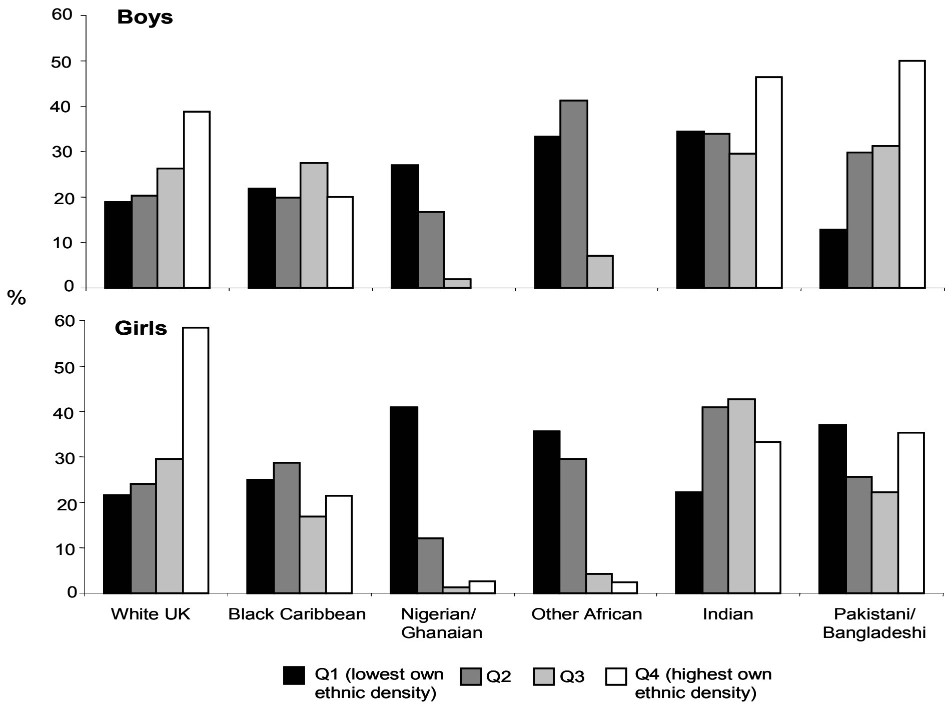


Figure 5.8 Residential neighbourhood private gardens and own ethnic density

Figure shows % living in most neighbourhoods with most private gardens (Q4)) by own ethnic density quartiles



5.1.5 Subjective opinions of residential neighbourhoods

The pupils were asked whether they liked their neighbourhood, whether they felt their neighbourhood was safe, and whether they thought their neighbourhood had a good reputation (Table 5.7). The majority of pupils felt that their neighbourhood was safe during the day, with the proportions generally similar at both 11-13yrs and 14-16yrs. For both boys and girls, and at both ages, the White UK pupils were the least likely to report that their neighbourhood was safe during the day. The proportions who reported their neighbourhood was safe at night were considerably lower than during the day for both boys and girls. Age effects varied by ethnicity; in some ethnic groups higher safety was reported at 11-13yrs (e.g. White UK girls) and in others at 14-16yrs (e.g. Nigerian/Ghanaian boys). Ethnic differences were greater at 14-16yrs than 11-13yrs; for both boys and girls Black Caribbeans, Nigerian/Ghanaians, Other Africans and Pakistani/Bangladeshis were significantly more likely to feel that their neighbourhood was safe at night than the White UK pupils.

The vast majority of girls and boys in all ethnic groups reported that they liked their neighbourhoods, although the proportions tended to be slightly lower at 14-16yrs compared to 11-13yrs. Compared to the White UK boys, the Black Caribbean, Nigerian/Ghanaian, Other African and Indian boys were significantly more likely to report liking their neighbourhood at both ages, and the Pakistani/Bangladeshi boys at 14-16yrs. For girls at 14-16yrs, the Black Caribbean, Indian and Pakistani/Bangladeshi girls were all significantly more likely to like their neighbourhood than the White UK girls.

Of the subjective measures, neighbourhood reputation showed the largest variation by age; the proportion who said their neighbourhood had a good reputation was lower at 14-16yrs in all ethnic groups (significantly so for boys in all groups, and for the White UK and Black Caribbean girls). At 14-16yrs, all of the ethnic minority girls were significantly more likely to report their area had a good reputation than the White UK girls. However for both genders and in all ethnic groups, well over half of the pupils reported that their neighbourhood had a good reputation, with the lowest proportion being for White UK girls (58%). Therefore overall, with the exception of safety at night, the pupils tended to view their neighbourhoods positively. However the White UK pupils were more likely than the other groups to report less favourably on their neighbourhoods despite their neighbourhoods being on average less deprived, having lower crime, and being greener than those of the other groups.

Table 5.7 Subjective opinion of neighbourhood by ethnicity and age

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys							
N		490	389	207	209	237	305
Safe during day	11-13	78.6 (74.9-82.2)	91.0 (88.1-93.9)*	88.9 (84.6-93.2)*	90.9 (87.0-94.8)*	86.1 (81.6-90.5)	85.2 (81.2-89.2)
	14-16	77.1 (73.4-80.9)	87.9 (84.7-91.2)*	86.5 (81.8-91.2)*	85.6 (80.9-90.4)	83.1 (78.3-87.9)	82.0 (77.6-86.3)
Safe at night	11-13	53.1 (48.6-57.5)	71.0 (66.4-75.5)*	53.6 (46.8-60.5)	61.7 (55.1-68.4)	62.9 (56.7-69.1)	58.7 (53.1-64.2)
	14-16	49.0 (44.5-53.4)	74.0 (70.0-78.4)*	69.6 (63.2-75.9)^*	70.8 (64.6-77.0)*	59.5 (53.2-65.8)	63.0 (57.5-68.4)*
Like Area	11-13	82.2 (78.8-85.6)	90.0 (87.0-93.0)*	90.3 (86.3-94.4)*	90.4 (86.4-94.5)*	92.8 (89.5-96.1)*	86.9 (83.1-90.7)
	14-16	75.1 (71.3-78.9)	83.8 (80.1-87.5)*	85.0 (80.1-89.9)*	85.2 (80.3-90.0)*	87.3 (83.1-91.6)*	87.2 (83.4-91.0)*
Good reputation	11-13	79.8 (76.2-83.4)	86.4 (83.0-89.8)	82.1 (76.9-87.4)	86.1 (81.4-90.8)	86.1 (81.6-90.5)	83.3 (79.1-87.5)
	14-16	63.3 (59.0-67.5)^	68.6 (64.0-73.3)^	64.3 (57.7-70.8)^	63.6 (57.1-70.2)^	75.5 (70.0-81.0)^*	72.1 (67.1-77.2)^
Girls							
N		380	389	297	177	181	140
Safe during day	11-13	76.8 (72.6-81.1)	85.3 (81.8-88.9)*	82.8 (78.5-87.1)	81.4 (75.6-87.1)	85.1 (79.8-90.3)	84.3 (78.2-90.4)
	14-16	74.2 (59.8-78.6)	85.1 (81.5-88.6)*	87.9 (84.1-91.6)*	80.2 (74.3-86.2)	86.7 (81.8-91.7)*	87.9 (82.4-93.3)*
Safe at night	11-13	53.1 (48.6-57.5)	57.8 (52.9-62.8)	55.6 (49.9-61.2)	53.1 (45.7-60.5)	57.5 (50.2-64.7)	54.3 (45.9-62.6)
	14-16	43.4 (38.4-48.4)^	59.4 (54.5-64.3)*	54.5 (48.8-60.2)*	57.1 (49.7-64.4)*	47.0 (39.6-54.3)	57.9 (49.6-66.1)*
Like Area	11-13	85.3 (81.7-88.8)	83.3 (79.6-87.0)	84.2 (80.0-88.3)	82.5 (76.8-88.1)	87.8 (83.0-92.7)	90.7 (85.8-95.6)
	14-16	72.4 (67.9-76.9)^	83.3 (79.6-87.0)*	78.1 (73.4-82.8)	79.1 (73.0-85.1)	90.1 (85.7-94.5)*	91.4 (86.7-96.1)*
Good reputation	11-13	76.6 (72.3-80.9)	82.3 (78.4-86.1)	75.4 (70.5-80.3)	78.0 (71.8-84.1)	81.8 (76.1-87.4)	81.4 (74.9-88.0)
	14-16	58.4 (53.4-63.4)^	70.2 (65.6-74.7)^*	66.0 (60.6-71.4)	69.5 (62.6-76.3)	72.9 (66.4-79.5)*	71.4 (63.9-79.0)*

*significantly different to White UK (non overlapping confidence intervals)

^ significantly different from 11-13yrs within ethnic groups (non overlapping confidence intervals)

5.1.6 Relationship between subjective and objective neighbourhood measures

Logistic regression analysis was used to determine if there was a relationship between the subjective and objective neighbourhood measures. The four binary outcomes analysed were: safe day, safe night, like area, and good reputation (all coded yes or no; in each case the odds of reporting yes was calculated). Four objective measures were chosen for this analysis; deprivation, crime, own ethnic density, and proportion of green space. These were added individually into the models with no other covariates. An interaction between each objective measure and ethnicity was then fitted, and where significant further models were run stratified by ethnicity.

Deprivation and crime

There was an inverse relationship between area deprivation and perceived area reputation and safety, and those living in the most deprived areas were the least likely to say that they liked their area (Table 5.8). For boys, there was a significant interaction between deprivation and ethnicity for liking area ($p=0.014$) and thinking it had a good reputation ($p<0.001$). In models stratified by ethnicity, the association with liking area was significant only for the White UK boys [relative to those in the most deprived areas (Q5), those in the other quartiles were significantly more likely to like their area: Q4 1.96 (1.42 to 2.70); Q3 2.71 (1.77 to 4.14); Q2 12.50 (3.84 to 40.67); Q1 8.41 (2.55 to 27.76)] and to a lesser extent the Pakistani/Bangladeshi boys [Q4 1.60 (1.05 to 2.43); Q3 3.38 (1.17 to 9.72); Q2 0.89 (0.17 to 4.66); none in Q1]. Although not significant, a pattern of those in less deprived areas liking their neighbourhoods more was also observed for the other groups with the exception of the Nigerian/Ghanaians. The association between good reputation and deprivation was only observed for the White UK boys; there was an increasing trend in the odds of reporting that their area had a good reputation as neighbourhood deprivation decreased: Q4 2.05 (1.44 to 2.91); Q3 3.35 (2.02 to 5.55); Q2 3.98 (1.66 to 9.52); Q1 5.66 (1.71 to 18.74). Increasing neighbourhood crime levels were inversely associated with perceived night safety and area reputation (Table 5.9).

Table 5.8 Association between area deprivation and subjective measures

(Odds Ratio and 95% CI, unadjusted for any other covariates)

	Safe during day	Safe at night	Like Area	Good reputation
Boys				
Q5 (most deprived)	1.00	1.00	1.00^	1.00^
Q4	1.30 (1.06 - 1.59)*	1.35 (1.16 - 1.57)*	1.31 (1.06 - 1.61)*	1.40 (1.18 - 1.66)*
Q3	1.83 (1.32 - 2.54)*	1.35 (1.08 - 1.67)*	1.60 (1.16 - 2.21)*	2.01 (1.53 - 2.63)*
Q2	1.84 (0.94 - 3.57)*	1.82 (1.15 - 2.87)*	1.90 (0.94 - 3.81)	5.00 (2.30 - 10.87)*
Q1	5.13 (1.24 - 21.24)*	2.26 (1.17 - 4.36)*	2.26 (0.81 - 6.33)	4.53 (1.62 - 12.7)*
Girls				
Q5 (most deprived)	1.00	1.00	1.00	1.00
Q4	1.52 (1.22 - 1.88)*	1.30 (1.10 - 1.52)*	1.31 (1.05 - 1.62)*	1.65 (1.37 - 1.98)*
Q3	1.47 (1.07 - 2.01)*	1.66 (1.31 - 2.10)*	1.62 (1.16 - 2.26)*	2.94 (2.15 - 4.02)*
Q2	6.17 (2.25 - 16.89)*	2.53 (1.62 - 3.95)*	3.20 (1.47 - 6.96)*	4.43 (2.28 - 8.58)*
Q1	5.85 (1.41 - 24.2)*	2.13 (1.14 - 3.95)*	2.62 (0.93 - 7.34)	4.18 (1.64 - 10.62)*

*Significantly different to reference group (most deprived), p<0.05

^Further analysis revealed a significant interaction with ethnicity for Like Area and Good Reputation for boys (further details in text).

Table 5.9 Association between residential neighbourhood crime and subjective measures

(Odds Ratio and 95% CI, unadjusted for any other covariates)

	Safe during day	Safe at night	Like Area	Good reputation
Boys				
Q5 (highest crime)	1.00	1.00	1.00	1.00
Q4	1.04 (0.84 - 1.27)	1.06 (0.91 - 1.24)	1.04 (0.84 - 1.28)	1.15 (0.97 - 1.38)
Q3	0.89 (0.69 - 1.14)	1.23 (1.01 - 1.50)*	0.87 (0.67 - 1.12)	0.88 (0.71 - 1.08)
Q2	1.52 (0.98 - 2.35)	1.43 (1.07 - 1.93)*	1.72 (1.08 - 2.75)*	1.77 (1.22 - 2.55)*
Q1	2.13 (0.65 - 6.99)	2.12 (0.99 - 4.51)	1.99 (0.61 - 6.53)	3.90 (1.19 - 12.76)*
Girls				
Q5 (highest crime)	1.00	1.00	1.00	1.00
Q4	1.07 (0.86 - 1.32)	1.25 (1.06 - 1.48)*	1.11 (0.89 - 1.38)	1.16 (0.97 - 1.39)
Q3	1.04 (0.80 - 1.35)	1.23 (1.01 - 1.50)*	0.88 (0.68 - 1.14)	1.26 (1.00 - 1.58)*
Q2	1.41 (0.91 - 2.18)	1.74 (1.27 - 2.39)*	1.17 (0.77 - 1.79)	1.94 (1.32 - 2.87)*
Q1	2.46 (0.75 - 8.07)	1.95 (0.97 - 3.92)	1.31 (0.50 - 3.41)	3.39 (1.19 - 9.64)*

*Significantly different to reference group (most deprived), p<0.05

Ethnic density

For White UK pupils, own ethnic density was positively associated with liking neighbourhood, neighbourhood reputation, and safety (Boys Table 5.10; Girls Table 5.11). Conversely, for Black Caribbean boys own ethnic density was inversely associated with safety at night, liking neighbourhood, and neighbourhood reputation. This pattern was not observed for the Black Caribbean girls. Nigerian/Ghanaian boys and girls, and Other African girls in high Black African density neighbourhoods (Q4) were significantly less likely to say their area had a good reputation compared to those in Q1. There were few significant effects for the other groups/subjective measures and associations that were found were not linear.

Table 5.10: Boys Own ethnic density and subjective measures

(Odds Ratio and 95% CI, unadjusted for any other covariates)

Own ethnic density	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Safe Day						
Q1 (low)	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.86 (1.25-2.76)*	0.46 (0.23-0.91)*	0.76 (0.34-1.71)	0.71 (0.32-1.58)	1.49 (0.71-3.10)	0.51 (0.28-0.93)*
Q3	2.74 (1.79-4.19)*	0.81 (0.39-1.68)	0.86 (0.38-1.95)	0.94 (0.41-2.17)	1.26 (0.62-2.54)	0.95 (0.50-1.81)
Q4	3.54 (2.25-5.55)*	0.58 (0.29-1.15)	1.15 (0.47-2.79)	1.50 (0.59-3.84)	0.82 (0.42-1.60)	0.99 (0.51-1.91)
Safe Night						
Q1 (low)	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.30 (0.91-1.86)	0.76 (0.48-1.21)	0.54 (0.31-0.96)	1.03 (0.59-1.79)	1.44 (0.85-2.44)	0.63 (0.40-1.01)
Q3	1.72 (1.20-2.46)*	0.91 (0.57-1.45)	0.65 (0.37-1.15)	1.39 (0.79-2.45)	1.55 (0.92-2.62)	0.71 (0.45-1.14)
Q4	2.03 (1.42-2.91)*	0.58 (0.37-0.91)*	0.70 (0.39-1.26)	1.85 (1.02-3.35)	0.82 (0.49-1.38)	0.64 (0.40-1.03)
Like Area						
Q1 (low)	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.13 (0.76-1.69)	0.50 (0.27-0.92)*	0.98 (0.46-2.08)	1.17 (0.53-2.59)	2.43 (1.01-5.82)*	0.76 (0.40-1.45)
Q3	2.61 (1.64-4.15)*	0.94 (0.48-1.84)	1.96 (0.82-4.65)	1.03 (0.48-2.24)	3.47 (1.33-9.07)*	1.20 (0.60-2.41)
Q4	1.74 (1.14-2.67)*	0.51 (0.28-0.95)*	1.60 (0.69-3.72)	1.94 (0.78-4.79)	1.14 (0.54-2.39)	0.93 (0.47-1.84)
Good reputation						
Q1 (low)	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.15 (0.80-1.66)	0.61 (0.37-1.00)*	0.52 (0.27-0.99)*	0.62 (0.33-1.17)	1.21 (0.64-2.28)	0.84 (0.48-1.47)
Q3	2.06 (1.39-3.06)*	0.81 (0.48-1.35)	0.66 (0.35-1.27)	0.75 (0.39-1.43)	1.74 (0.89-3.41)	0.81 (0.47-1.41)
Q4	2.72 (1.80-4.11)*	0.53 (0.32-0.86)*	0.52 (0.27-0.98)*	0.69 (0.36-1.31)	0.91 (0.49-1.70)	0.65 (0.38-1.13)

Table 5.11: Girls own ethnic density and subjective measures

(Odds Ratio and 95% CI, unadjusted for any other covariates)

Own ethnic density	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Safe Day						
Q1 (low)	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.14 (0.75-1.76)	0.80 (0.46-1.40)	0.63 (0.34-1.17)	0.57 (0.27-1.20)	1.18 (0.50-2.80)	1.25 (0.46-3.38)
Q3	2.02 (1.28-3.21)*	0.71 (0.41-1.22)	1.67 (0.80-3.49)	0.93 (0.42-2.07)	3.54 (1.11-11.30)*	1.11 (0.42-2.93)
Q4	3.68 (2.17-6.24)*	1.39 (0.75-2.57)	0.73 (0.38-1.38)	0.76 (0.35-1.65)	0.48 (0.23-1.02)	0.79 (0.32-1.97)
Safe Night						
Q1 (low)	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.38 (0.91-2.08)	1.15 (0.77-1.73)	0.73 (0.46-1.16)	0.73 (0.40-1.32)	1.42 (0.79-2.55)	1.53 (0.78-3.01)
Q3	2.43 (1.61-3.67)*	0.99 (0.66-1.48)	0.76 (0.48-1.19)	0.68 (0.38-1.23)	1.42 (0.79-2.55)	0.82 (0.42-1.59)
Q4	3.24 (2.13-4.93)*	1.22 (0.81-1.82)	0.64 (0.40-4.02)	0.99 (0.54-1.81)	1.19 (0.67-2.13)	1.23 (0.63-2.39)
Like Area						
Q1 (low)	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.62 (1.04-2.55)*	1.26 (0.75-2.12)	0.94 (0.54-1.62)	1.62 (0.78-3.38)	1.54 (0.60-3.96)	1.40 (0.42-4.64)
Q3	2.95 (1.79-4.87)*	1.06 (0.64-1.76)	1.46 (0.82-2.59)	1.52 (0.74-3.13)	2.55 (0.86-7.56)	0.74 (0.26-2.11)
Q4	3.42 (2.03-5.78)*	1.63 (0.94-2.82)	1.73 (0.94-3.19)	1.55 (0.74-3.25)	0.75 (0.33-1.71)	1.80 (0.50-6.46)
Good reputation						
Q1 (low)	1.00	1.00	1.00	1.00	1.00	1.00
Q2	0.91 (0.61-1.37)	0.95 (0.59-1.53)	0.73 (0.43-1.24)	0.68 (0.33-1.38)	1.22 (0.63-2.36)	0.82 (0.37-1.81)
Q3	1.63 (1.07-2.48)*	0.88 (0.55-1.42)	0.63 (0.38-1.05)	0.65 (0.32-1.31)	1.97 (0.96-4.03)	0.67 (0.31-1.45)
Q4	4.18 (2.54-6.89)*	0.79 (0.49-1.26)	0.56 (0.34-0.94)*	0.46 (0.23-0.93)*	1.47 (0.75-2.91)	1.07 (0.47-2.43)

*Significantly different to reference group (most deprived), $p<0.05$

Green space

Of the different land types, it was thought that green space could be the most likely to have an association with subjective neighbourhood opinions (on reputation or likeability in particular). However overall there were no significant associations between the proportion of green space in an area and perceived safety, likeability, or reputation (Table 5.12). Interactions with ethnicity were significant for safety at night for boys ($p<0.01$) and girls ($p<0.05$) and with liking area for boys ($p<0.01$). In stratified models, liking an area was not associated with proportion of green space for any ethnic group among the boys. Black Caribbean boys living in the greenest areas were significantly less likely to report feeling safe at night than those in the least green neighbourhoods (Q2 0.85, 0.46 to 1.22; Q3 0.67, 0.43 to 1.06; Q4 0.59, 0.37 to 0.95). In contrast, for Other African boys more greenery was associated with an increase in reported safety at night (Q2 1.25, 0.69 to 2.25; Q3 1.75, 0.99 to 3.09; Q4 2.10, 1.16 to 3.81). There were no significant relationships for boys in the other ethnic groups, or in any of the groups for girls.

Table 5.12: Green space and neighbourhood reputation

(Odds Ratio and 95% CI, unadjusted for any other covariates)

Green space	Safe during day	Safe at night	Like Area	Good reputation
Boys				
Q1 (lowest proportion)	1.00	1.00^	1.00^	1.00
Q2	1.17 (0.91 - 1.50)	0.88 (0.73 - 1.06)	1.00 (0.77 - 1.30)	0.82 (0.66 - 1.02)
Q3	1.17 (0.91 - 1.50)	1.10 (0.91 - 1.33)	0.94 (0.73 - 1.22)	0.87 (0.70 - 1.08)
Q4	1.18 (0.92 - 1.52)	1.06 (0.88 - 1.28)	0.92 (0.71 - 1.19)	0.94 (0.76 - 1.17)
Girls				
Q1 (lowest proportion)	1.00	1.00^	1.00	1.00
Q2	0.89 (0.69 - 1.16)	0.94 (0.77 - 1.15)	0.92 (0.70 - 1.20)	0.85 (0.68 - 1.06)
Q3	0.99 (0.76 - 1.29)	1.10 (0.82 - 1.22)	0.92 (0.70 - 1.20)	0.84 (0.67 - 1.06)
Q4	0.93 (0.72 - 1.21)	1.01 (0.83 - 1.24)	0.79 (0.61 - 1.03)	0.95 (0.76 - 1.19)

^Further analysis revealed a significant interaction with ethnicity for Safe at Night (boys and girls) and Like Area (boys) (further details in text).

5.2 Neighbourhood environment of the schools

In addition to spending time in their residential neighbourhoods, many pupils would also have spent time in the area surrounding their school. Many would have walked through their school's neighbourhood on their way to and from school (either because they were walking to school directly from home or because they were walking from a bus stop or train station in their school's neighbourhood). Furthermore some pupils left the school grounds at lunchtime, often to buy food.

All of the schools in DASH were situated in one of London's inner-city boroughs. Whilst this inevitably resulted in some similarities in their surrounding areas (e.g. none of them had a rural setting), there were many differences in the neighbourhoods in which they were situated, and hence in the areas in which their pupils spent time each school day (Table 5.13). (As the school neighbourhoods changed little between the two waves of the study, figures from one time point (2006) are presented). Each of the characteristics is discussed in turn.

Table 5.13: Summary of neighbourhoods of the DASH schools

Characteristic[1]		Mean	Minimum	Maximum
Deprivation	IMD rank (1=most deprived)	8069	1076	27384
Crime	Crime rank (1=highest crime)	7384	67	19130
Ethnic density	White British (%)	48.9	7.5	85.0
	Black Caribbean (%)	8.9	1.4	19.9
	Black African (%)	8.3	0.7	22.4
	Indian (%)	6.2	0.2	27.9
	Pakistani (%)	3.4	0	24.3
	Bangladeshi (%)	2.0	0	17.3
Land Use	Roads (%)	16.8	3.1	28.3
	Domestic buildings (%)	6.0	1.8	27.1
	Non-domestic buildings (%)	7.0	0.4	19.2
	Green space (%)	23.1	2.2	83.5
	Domestic gardens (%)	26.6	3.9	52.7

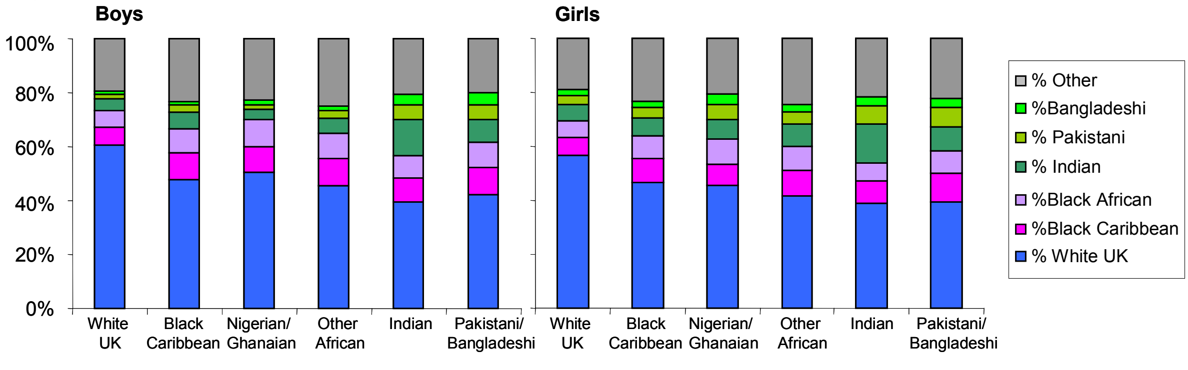
[1]Figures in table refer to 2001 data for ethnic density, 2005 data for land use, 2006 data for deprivation and crime.

5.2.1 Ethnic density

The schools were located in neighbourhoods which varied in their ethnic composition. For example, the White UK density of the school neighbourhoods ranged from 7.5% to 85%, and the Pakistani density from 0% to 24% (Table 5.13). The proportions of the other ethnic groups also varied widely. Most of the schools were located in neighbourhoods with low proportions of resident Pakistanis and Bangladeshis, and to a lesser extent Indians. Proportions of Black Caribbeans and Black Africans in the schools' neighbourhoods were generally higher, although neither comprised more than 23% of any of the schools' neighbourhoods.

An examination of the ethnic density of schools neighbourhoods by ethnicity of the DASH pupils revealed that the White UK pupils attended schools located in neighbourhoods with a higher mean proportion of White UK residents compared to pupils of other ethnic groups (Figure 5.9). The Indian and Pakistani/Bangladeshi pupils attended schools situated in neighbourhoods with the lowest mean proportion of White UK residents. For example, an average of 60% of the people in the neighbourhoods of the White UK boys' schools were White UK compared to 39% of the people in the areas around the Indian boys' schools. The highest level of ethnic clustering after the White UK group was for the Indians. Indians made up an average of 14% of the population in the areas surrounding the Indian girls' schools and 13% of the Indian boys' schools. By way of comparison, they only account for 4% of the population in the neighbourhoods of the White UK and Nigerian/Ghanaian boys' schools.

Figure 5.9: Ethnic density of school neighbourhood



5.2.2 Deprivation and crime

The areas in which the schools were located covered a large range of deprivation levels, as measured by the IMD. The distribution of the IMD ranks of school neighbourhoods was positively skewed; most of the schools were located in relatively deprived LSOAs. In terms of IMD quintiles, where 1 is the most affluent and 5 the most deprived, there was only one school in Q1, none in Q2 at 11-13yrs and one at 14-16yrs. There was also a large range in crime rankings; one school was in the top 2% of highest crime areas in England while another was in an LSOA ranked over 19000 places below. However this lowest crime area did not make it into the top 40% of low crime areas in England; emphasising that all the schools were located in relatively high crime areas compared to the country as a whole. This reflects that all the schools were in London, and while crime levels vary from one part of London to another, crime levels in this city are relatively high compared to many other areas in England. Over half of the DASH schools were in the highest crime quintile at Wave 1 (27 schools, 55%), and the vast majority of schools (40 of them) were in the two highest crime quintiles (Q4 and Q5); no schools were in crime Q1. This clustering in deprived, high crime areas relates to the sampling strategy employed in DASH; schools had to be located in areas with at least 5% Black Caribbeans in the neighbourhood and in the school.

Deprivation and crime quintiles of school neighbourhoods were compared by ethnicity (Table 5.14). Because of the small number of schools in Q1 and Q2 for both deprivation and crime, quartiles 1, 2 and 3 were combined for the purposes of this analysis. The White UK and Indian pupils were the most likely to attend a school located in deprivation quintiles 1,2 or 3 (although proportions dropped in both these groups between 11-13yrs and 14-16yrs). Conversely, the Black Caribbean, Nigerian/Ghanaian, and Other African pupils were the most likely to attend a school located in Q5. The overall pattern was similar for both boys and girls. The vast majority of the pupils in every ethnic group attended a school in a relatively high crime area. However, the White UK and the Indian groups (both boys and girls) were the least likely to attend a school in the highest crime quintile.

As the sample was restricted to pupils who attended the same school at both waves of the study, any differences by age were due to areas being ranked differently at the different time points (2004 and 2007). The deprivation and crime quartiles are based on rank (rather than an absolute score), meaning that changes in quartile classification between waves could be due to a neighbourhood itself changing, due to other neighbourhoods changing, or both. The largest difference by age was observed for the girls classified to a school in deprivation quintiles 1,2 or 3; proportions were lower in all groups at 14-16yrs compared to 11-13yrs. This was due to ten of the schools being in these quartiles at 11-13yrs but only seven at 14-16yrs.

Table 5.14 School neighbourhood deprivation and crime by gender, age, and ethnicity

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys							
N		490	389	207	209	237	305
Deprivation							
Q1,2,3	11-13	40.8 (36.4-45.2)	24.9 (20.6-29.3)*	8.7 (4.8-12.6)*	16.3 (11.2-21.3)*	38.8 (32.6-45.1)	16.4 (12.2-20.6)*
	14-16	31.8 (27.7-36.0)^	18.8 (14.9-22.7)*	15.5 (10.5-20.4)*	16.7 (11.6-21.9)*	20.3 (15.1-25.4)^*	10.2 (6.8-13.6)*
Q5 (Most deprived)	11-13	30.6 (26.5-34.7)	51.2 (46.2-56.1)*	57.0 (50.2-63.8)*	55.0 (48.2-61.8)*	36.7 (30.5-42.9)	46.2 (40.6-51.9)*
	14-16	37.6 (33.2-41.9)	49.9 (44.9-54.9)*	57.5 (50.7-64.3)*	60.8 (54.1-67.4)*	37.1 (30.9-43.3)	55.1 (49.5-60.7)*
Crime							
Q2,3	11-13	19.4 (15.9-22.9)	12.1 (8.8-15.3)*	7.2 (3.7-10.8)*	12.9 (8.3-17.5)	26.2 (20.5-31.8)	19.3 (14.9-23.8)
	14-16	17.3 (14.0-20.7)	13.9 (10.4-17.3)	9.7 (5.6-13.7)*	13.4 (8.7-18.1)	30.4 (24.5-36.3)	23.9 (19.1-28.8)
Q5 (Highest crime)	11-13	42.2 (37.9-46.6)	60.2 (55.3-65.0)*	63.8 (57.2-70.4)*	66.0 (59.6-72.5)*	41.8 (35.4-48.1)	62.0 (56.5-67.4)*
	14-16	48.4 (43.9-52.8)	68.6 (64.0-73.3)*	79.7 (74.2-85.2)^*	73.2 (67.2-79.3)*	50.2 (43.8-56.6)	58.4 (52.8-63.9)
Girls							
N		380	389	297	177	181	140
Deprivation							
Q1,2,3	11-13	38.7 (33.8-43.6)	26.7 (22.3-31.2)*	25.3 (20.3-30.2)*	20.3 (14.4-26.3)*	48.1 (40.7-55.4)	19.3 (12.7-25.9)*
	14-16	30.0 (25.4-34.6)	17.0 (13.2-20.7)^*	7.1 (4.1-10.0)^*	9.0 (4.8-13.3)^*	21.0 (15.0-27.0)^	10.7 (5.5-15.9)*
Q5 (Most deprived)	11-13	32.9 (28.1-37.6)	47.0 (42.1-52.0)*	55.6 (49.9-61.2)*	47.5 (40.0-54.9)*	29.8 (23.1-36.6)	31.4 (23.6-39.2)
	14-16	35.0 (30.2-39.8)	45.5 (40.5-50.5)*	51.5 (45.8-57.2)*	52.5 (45.1-60.0)*	32.0 (25.2-38.9)	38.6 (30.4-46.7)
Crime							
Q2,3	11-13	24.2 (19.9-28.5)	10.8 (7.7-13.9)*	6.4 (3.6-9.2)*	16.4 (10.9-21.9)	24.9 (18.5-31.2)	20.7 (13.9-27.5)
	14-16	18.7 (14.7-22.6)	16.7 (13.0-20.4)	15.2 (11.1-19.3)^	15.8 (10.4-21.2)	20.4 (14.5-26.4)	20.0 (13.3-26.7)
Q5 (Highest crime)	11-13	42.9 (37.9-47.9)	60.9 (56.1-65.8)*	64.6 (59.2-70.1)*	54.8 (47.4-62.2)	38.7 (31.5-45.8)	60.0 (51.8-68.2)*
	14-16	35.0 (30.2-39.8)	50.6 (45.7-55.6)^*	52.5 (45.1-60.0)	52.5 (45.1-60.0)*	39.2 (32.0-46.4)	37.1 (29.0-45.2)^

*Significantly different to White UK (non-overlapping confidence intervals)

^Significantly different, within ethnic group, at 14-16yrs compared to 11-13yrs

5.2.3 Land Use

The neighbourhoods in which the schools were situated varied widely in terms of land use. This was particularly evident for green space; the school with the least amount was in an LSOA where only 2% of the land was green space, and the school with the most was in an LSOA where 84% of the land was green space (Table 5.13). An area with more domestic buildings and gardens could be relatively residential and suburban; in contrast less green space and more non-domestic buildings and roads is probably indicative of a more urban environment. An examination of the distributions of each of the neighbourhood characteristics showed that the distribution for green space was particularly skewed, with most schools being located in neighbourhoods with a relatively low percentage of green space.

The mean land use of the school neighbourhoods by ethnicity and sex is summarised in Figure 5.10. The White UK and Indian pupils were the most likely to attend a school in an area with a low (Q1) proportion of domestic buildings (Boys Table 5.15; Girls Table 5.16). The White UK pupils were also the most likely to be in Q1 of non-domestic buildings. The Nigerian/Ghanaian boys were the most likely to attend a school with a high proportion of non-domestic buildings (over 40% attended a school in Q4). The White UK and Indian pupils were the most likely to attend schools in areas with a low proportion of roads, with ethnic differences being particularly apparent for the boys. The Nigerian/Ghanaian boys and girls were the most likely to attend a school in an area with a high proportion of roads (over 40% of them were in Q4 compared to less than 20% of Indian and Pakistani/Bangladeshi pupils.

Some of the largest ethnic differences in school neighbourhood land use were observed for green space; the Nigerian/Ghanaian pupils were the least likely to attend a school which was located in an area with a high proportion of green space (only 12% of the boys and 6% of the girls were in a school in Q4 compared to over a third of the White UK boys and girls and Indian boys). Finally, the Indian pupils were the most likely to attend a school in Q4 of gardens; a third of the boys and almost half of the girls so compared to less than 20% of the White UK boys and girls, and Nigerian/Ghanaian and Pakistani/Bangladeshi boys.

Figure 5.10: Schools' neighbourhood land use by ethnicity and sex

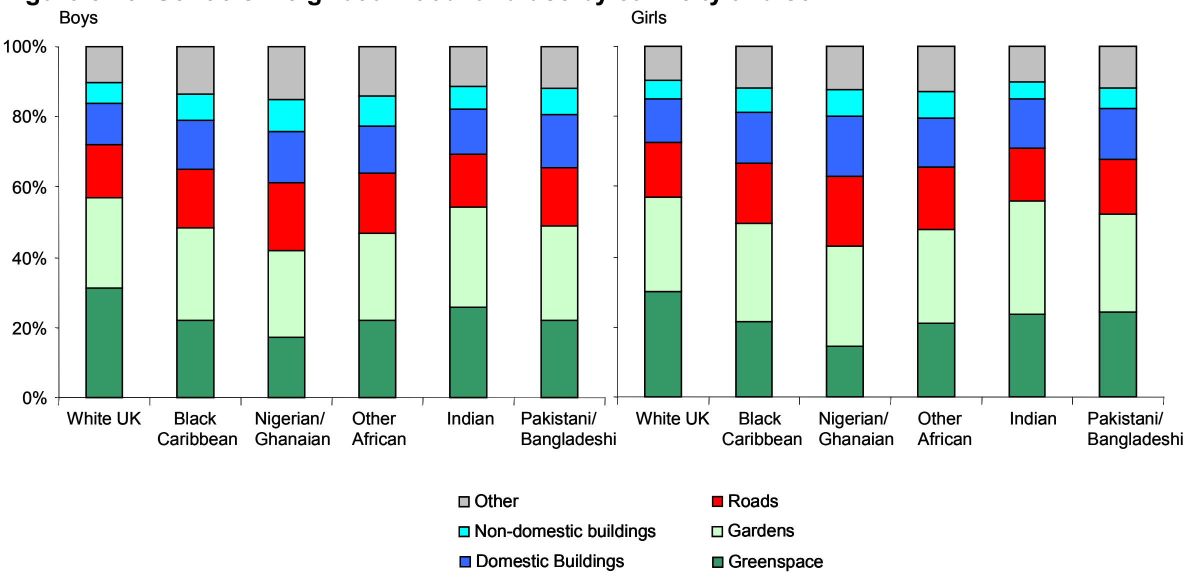


Table 5.15 Boys: School neighbourhood land use by age and ethnicity

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N		490	389	207	209	237	305
Domestic Buildings							
Q1 (Least)	11-13	42.2 (37.9-46.6)	26.7 (22.3-31.2)*	19.3 (13.9-24.7)*	23.0 (17.2-28.7)*	36.3 (30.1-42.5)	26.9 (21.9-31.9)*
	14-16	38.4 (34.0-42.7)	23.9 (19.7-28.2)*	17.9 (12.6-23.1)*	20.1 (14.6-25.6)*	36.3 (30.1-42.5)	24.6 (19.7-29.5)*
Q4 (Most)	11-13	19.0 (15.5-22.5)	19.3 (15.3-23.2)	23.7 (17.8-29.5)	16.3 (11.2-21.3)	21.1 (15.9-26.3)	37.0 (31.6-42.5)*
	14-16	16.9 (13.6-20.3)	24.2 (19.9-28.4)	25.6 (19.6-31.6)	20.6 (15.0-26.1)	20.7 (15.5-25.9)	35.7 (30.3-41.1)*
Non Domestic Buildings							
Q1 (Least)	11-13	30.4 (26.3-34.5)	19.5 (15.6-23.5)*	15.0 (10.1-19.9)*	21.5 (15.9-27.1)	14.8 (10.2-19.3)*	16.4 (12.2-20.6)*
	14-16	37.1 (32.8-41.4)	19.8 (15.8-23.8)*	15.5 (10.5-20.4)*	17.2 (12.1-22.4)	14.3 (9.9-18.8)*	15.7 (11.6-19.8)*
Q4 (Most)	11-13	12.4 (9.5-15.4)	30.1 (25.5-34.7)*	42.0 (35.2-48.8)*	33.0 (26.6-39.4)*	8.0 (4.5-11.5)	9.8 (6.5-13.2)
	14-16	11.6 (8.8-14.5)	29.6 (25.0-34.1)*	44.4 (37.6-51.3)*	33.0 (26.6-39.4)*	12.2 (8.0-16.4)	26.6 (21.6-31.5)^*
Roads							
Q1 (Least)	11-13	41.2 (36.9-45.6)	26.2 (21.8-30.6)*	15.0 (10.1-19.9)*	23.9 (18.1-29.8)*	41.8 (35.4-48.1)	24.3 (19.4-29.1)*
	14-16	39.4 (35.0-43.7)	26.2 (21.8-30.6)*	15.9 (10.9-21.0)*	25.4 (19.4-31.3)*	42.6 (36.3-49.0)	23.6 (18.8-28.4)
Q4 (Most)	11-13	12.2 (9.3-15.2)	23.1 (18.9-27.3)*	45.4 (38.6-52.2)*	26.3 (20.3-32.3)*	5.1 (2.3-7.9)*	10.2 (6.8-13.6)
	14-16	18.6 (15.1-22.0)	27.0 (22.6-31.4)*	45.9 (39.0-52.7)*	27.3 (21.2-33.4)	7.2 (3.9-10.5)*	12.5 (8.7-16.2)
Green Space							
Q1 (Least)	11-13	20.8 (17.2-24.4)	34.2 (29.5-39.0)*	40.1 (33.4-46.8)*	29.7 (23.4-35.9)	35.4 (29.3-41.6)*	31.5 (26.2-36.7)*
	14-16	20.8 (17.2-24.4)	28.3 (23.8-32.8)	38.6 (32.0-45.3)*	24.4 (18.5-30.3)	46.4 (40.0-52.8)*	45.2 (39.6-50.9)*
Q4 (Most)	11-13	38.2 (33.8-42.5)	20.6 (16.5-24.6)*	11.6 (7.2-16.0)*	20.1 (14.6-25.6)*	34.6 (28.5-40.7)	27.2 (22.2-32.2)*
	14-16	38.2 (33.8-42.5)	20.6 (16.5-24.6)*	11.6 (7.2-16.0)*	20.1 (14.6-25.6)*	34.6 (28.5-40.7)	27.2 (22.2-32.2)*
Gardens							
Q1 (Least)	11-13	28.8 (24.8-32.8)	30.6 (26.0-35.2)	27.1 (21.0-33.2)	34.4 (28.0-41.0)	37.6 (31.3-43.8)	28.2 (23.1-33.3)
	14-16	28.8 (24.8-32.8)	30.6 (26.0-35.2)	27.1 (21.0-33.2)	34.4 (28.0-41.0)	37.6 (31.3-43.8)	28.2 (23.1-33.3)
Q4 (Most)	11-13	16.3 (13.0-19.6)	22.4 (18.2-26.5)	16.9 (11.8-22.1)	15.8 (10.8-20.8)	32.5 (26.5-38.5)*	8.5 (5.4-11.7)*
	14-16	16.9 (13.6-20.3)	22.1 (18.0-26.2)	11.1 (6.8-15.4)	15.8 (10.8-20.8)	34.2 (28.1-40.3)*	17.7 (13.4-22.0)^

*Significantly different to White UK (non-overlapping confidence intervals)

Table 5.16 Girls: School neighbourhood land use by age and ethnicity

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N		380	389	297	177	181	140
Domestic Buildings							
Q1 (Least)	11-13	36.6 (31.7-41.4)	19.3 (15.3-23.2)*	12.1 (8.4-15.9)*	19.8 (13.8-25.7)*	21.5 (15.5-27.6)*	17.9 (11.4-24.3)*
	14-16	35.8 (30.9-40.6)	18.3 (14.4-22.1)	12.8 (9.0-16.6)*	20.9 (14.9-27.0)*	23.8 (17.5-30.0)*	20.7 (13.9-27.5)
Q4 (Most)	11-13	22.4 (18.2-26.6)	36.5 (31.7-41.3)*	57.6 (51.9-63.2)*	29.4 (22.6-36.2)	17.7 (12.1-23.3)	20.0 (13.3-26.7)
	14-16	20.8 (16.7-24.9)	35.2 (30.5-40.0)*	55.9 (50.2-61.6)*	26.0 (19.5-32.5)	16.6 (11.1-22.0)	17.1 (10.8-23.5)
Non Domestic Buildings							
Q1 (Least)	11-13	35.5 (30.7-40.4)	31.1 (26.5-35.7)	19.2 (14.7-23.7)*	25.4 (18.9-31.9)	26.5 (20.0-33.0)	28.6 (21.0-36.1)
	14-16	38.4 (33.5-43.3)	32.9 (28.2-37.6)	19.9 (15.3-24.4)*	23.2 (16.9-29.4)*	27.6 (21.0-34.2)	27.9 (20.3-35.4)
Q4 (Most)	11-13	13.2 (9.7-16.6)	20.3 (16.3-24.3)	24.2 (19.3-29.1)*	28.2 (21.6-34.9)*	2.2 (0.0-4.4)*	10.7 (5.5-15.9)
	14-16	13.2 (9.7-16.6)	20.3 (16.3-24.3)	24.2 (19.3-29.1)*	28.2 (21.6-34.9)*	2.2 (0.0-4.4)*	10.7 (5.5-15.9)
Roads							
Q1 (Least)	11-13	35.3 (30.4-40.1)	26.7 (22.3-31.2)	12.1 (8.4-15.9)*	25.4 (18.9-31.9)	35.4 (28.3-42.4)	25.7 (18.4-33.0)
	14-16	34.5 (29.7-39.3)	26.5 (22.1-30.9)	11.1 (7.5-14.7)*	25.4 (18.9-31.9)	35.9 (28.9-43.0)	25.0 (17.7-32.3)
Q4 (Most)	11-13	21.3 (17.2-25.5)	27.0 (22.6-31.4)	46.8 (41.1-52.5)*	28.2 (21.6-34.9)	13.3 (8.3-18.2)	16.4 (10.2-22.6)
	14-16	22.4 (18.2-26.6)	24.4 (20.1-28.7)	41.4 (35.8-47.0)*	26.0 (19.5-32.5)	15.5 (10.2-20.8)	17.9 (11.4-24.3)
Green Space							
Q1 (Least)	11-13	18.7 (14.7-22.6)	22.4 (18.2-26.5)	49.2 (43.4-54.9)*	26.0 (19.5-32.5)	36.5 (29.4-43.5)*	10.7 (5.5-15.9)
	14-16	19.2 (15.2-23.2)	22.9 (18.7-27.1)	50.5 (44.8-56.2)*	28.2 (21.6-34.9)	42.5 (35.3-49.8)*	19.3 (12.7-25.9)
Q4 (Most)	11-13	33.2 (28.4-37.9)	17.5 (13.7-21.3)*	6.4 (3.6-9.2)*	19.2 (13.3-25.1)*	27.1 (20.5-33.6)	29.3 (21.7-36.9)
	14-16	33.2 (28.4-37.9)	17.5 (13.7-21.3)*	6.4 (3.6-9.2)*	19.2 (13.3-25.1)*	27.1 (20.5-33.6)	29.3 (21.7-36.9)
Gardens							
Q1 (Least)	11-13	26.8 (22.4-31.3)	21.9 (17.7-26.0)	13.8 (9.9-17.8)*	26.0 (19.5-32.5)	21.5 (15.5-27.6)	20.7 (13.9-27.5)
	14-16	26.8 (22.4-31.3)	21.9 (17.7-26.0)	13.8 (9.9-17.8)*	26.0 (19.5-32.5)	21.5 (15.5-27.6)	20.7 (13.9-27.5)
Q4 (Most)	11-13	19.2 (15.2-23.2)	38.6 (33.7-43.4)*	39.1 (33.5-44.6)*	28.2 (21.6-34.9)	48.6 (41.3-56.0)*	22.1 (15.2-29.1)
	14-16	19.7 (15.7-23.8)	36.5 (31.7-41.3)*	36.7 (31.2-42.2)*	26.6 (20.0-33.1)	48.6 (41.3-56.0)*	22.1 (15.2-29.1)

*Significantly different to White UK (non-overlapping confidence intervals)

5.2.4 Comparison of school and residential neighbourhoods

Only a small proportion of pupils (<3% at either age for both boys and girls) lived in the same neighbourhood (LSOA) as their school and around 11% lived in the same MSOA (middle super output area level - an area with a mean population of 7200). (It is important to emphasise that pupils may have lived very close to their school but their residential address may have been in a different LSOA or MSOA). Despite few pupils living in the same LSOA or MSOA as their school, a comparison of the characteristics of the school and residential neighbourhoods revealed that many attended a school which was located in an area similar to the one in which they lived in terms of deprivation, crime and ethnic density.

Deprivation and crime

Due to very small number of pupils in some ethnic groups living in the least deprived/lowest crime neighbourhoods, quintiles 1,2 and 3 were aggregated for this analysis. Results are presented for 11-13yrs and were similar at 14-16yrs. Those living in the most deprived neighbourhoods (Q5) were the most likely to attend a school in a highly deprived neighbourhood (Figure 5.11). For example, 71% of Indian boys who lived in deprivation Q5 attended a school in deprivation Q5, compared to only 19% of those living in Q4 and 5% of those in Q1,2 and 3. A similar pattern was observed within the other ethnic and gender groups with the exception of the Nigerian/Ghanaian boys, for whom proportions attending schools in the most deprived areas were relatively high irrespective of residential area deprivation. Pupils living in higher crime areas were the most likely to attend a school located in a higher crime area, although the gradients across quintiles were not as steep as observed for deprivation for most groups, an exception being the Pakistani/Bangladeshi girls (Figure 5.12).

Figure 5.11: Deprivation - comparison between residential and school neighbourhoods

Figure shows % attending school in Q5 (most deprived areas) by residential deprivation level at 11-13yrs

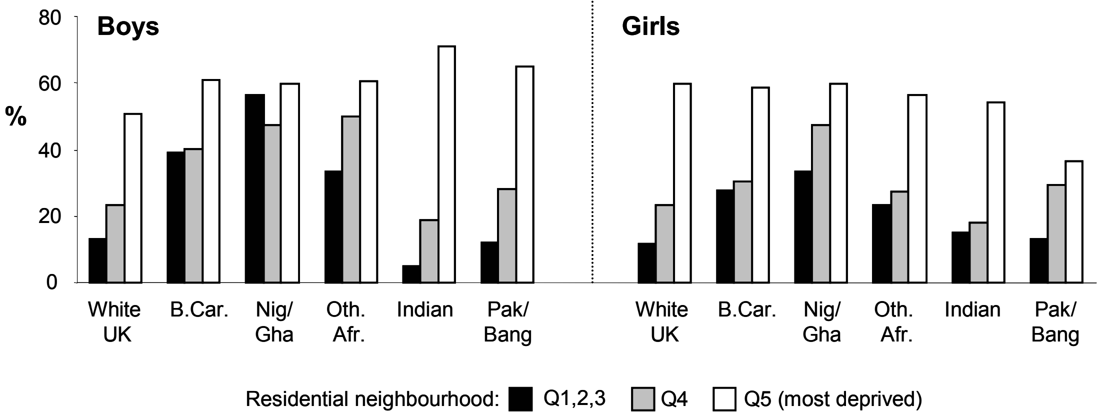
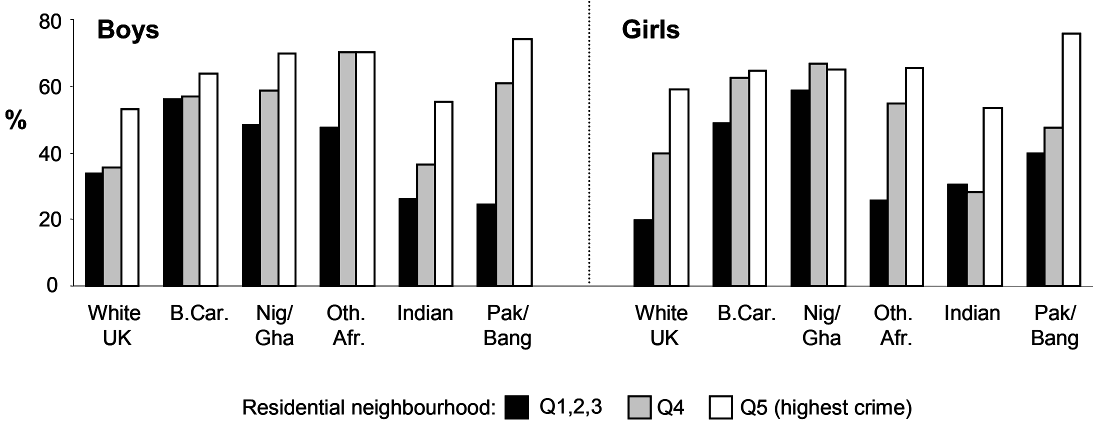


Figure 5.12: Crime levels - comparison between residential and school neighbourhoods

Figure shows % attending school in Q5 (most deprived areas) by residential deprivation level at 11-13yrs

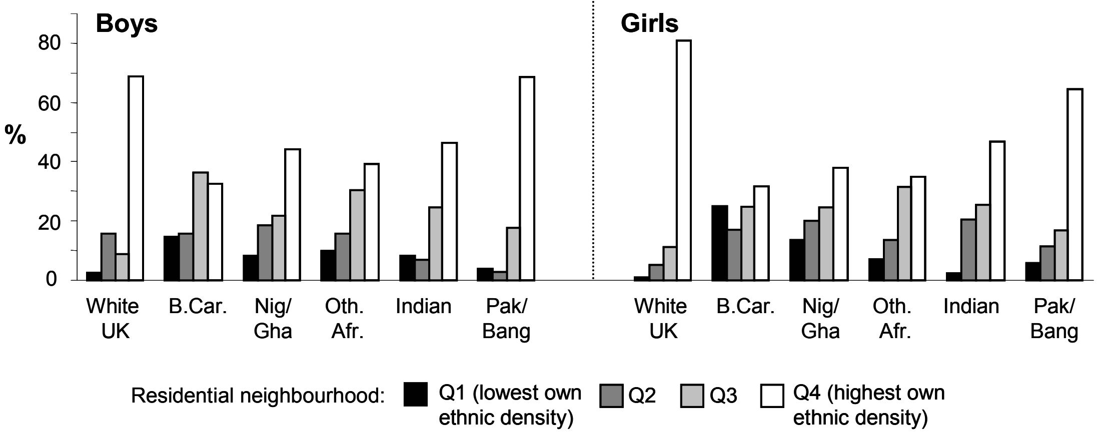


Ethnic density

Pupils' schools tended to be located in neighbourhoods similar to their residential neighbourhoods in terms of own ethnic density (Figure 5.13). The White UK pupils, followed by the Pakistani/Bangladeshis, showed the strongest relationship between home and school neighbourhood own ethnic density. The vast majority of White UK pupils who lived in a neighbourhood in Q4 (highest White UK density) attended a school in Q4 (at 11-13yrs 69% for boys, 81% for girls). Less of a relationship was seen for Black Caribbeans; many of those who lived in areas with the highest concentrations of Black Caribbeans attended a school in a neighbourhood with a lower proportion of Black Caribbeans. This may be due to there being less secondary schools in areas of high Black Caribbean density, or that neighbourhoods of high Black Caribbean density are often surrounded by areas of differing ethnic density, or that they are choosing to travel further from home e.g. to attend church schools.

Figure 5.13: Ethnic density - comparison between residential and school neighbourhoods

Figure shows % attending school in Q4 (highest own ethnic density) by residential own ethnic density at 11-13yrs



5.2.5 Key Findings - neighbourhood environments

- The DASH pupils lived and attended schools in ethnically diverse neighbourhoods. There was less ethnic clustering in neighbourhoods than schools for the ethnic minority groups, but more neighbourhood than school clustering for the White UK pupils.

- The White UK and Indian pupils were the most likely to live in the least deprived areas, and the Nigerian/Ghanaians and Other Africans the most likely to live in the most deprived areas. However, the majority of pupils in every ethnic group lived in relatively deprived, high crime neighbourhoods.

- The more deprived areas had higher proportions of roads and buildings, and lower proportions of gardens and green space. The White UK pupils were the most likely to live in more residential, less built-up areas with a higher proportion of green space than the other ethnic groups.

- Increasing own ethnic density was associated with greater neighbourhood deprivation and crime for the Black Caribbean, Nigerian/Ghanaian, Other African, and Pakistani/Bangladeshi pupils. The opposite pattern was observed for the White UK and Indian pupils.

- The pupils were generally positive about their residential neighbourhoods. However despite the White UK pupils living in less deprived, lower crime, greener areas than the other ethnic groups, they often reported least favourably on their areas and were the least likely to report that their neighbourhood was safe during the day. Girls were less likely than boys to think that their neighbourhood was safe at night.

- Greater own ethnic density was associated with neighbourhoods being perceived more positively for the White UK pupils but more negatively for the Black Caribbean boys.

- Pupils generally attended schools which were located in areas similar to their residential neighbourhoods in terms of deprivation, crime and ethnic density.

5.3 The association between neighbourhood characteristics and body size

The associations between the neighbourhood characteristics (both residential and school) and BMI and Waist SDS were examined. The aim was to determine whether there were any significant associations, and whether neighbourhood characteristics explained any variance in body size.

As neighbourhood was not included as a level in the models, the residential neighbourhood variables were included as individual level covariates. The school neighbourhood variables were added as school-level covariates. All of the variables were added individually to the baseline model to determine their association with BMI SDS/Waist SDS after adjusting for age, pubertal status, ethnicity and height. The significance of each variable, and its impact on the between school variance, was assessed. The models including the ethnic density variables were all stratified by ethnicity. For the other variables, models were first run on the overall sample then models were refitted with an interaction term between ethnicity and the variable being assessed; this was to determine whether the association between the given variable and the outcomes differed by ethnic group. Where this interaction was significant ($p<0.05$), models stratified by ethnicity were built to further examine ethnic differences in the association.

5.3.1 Ethnic Density and body size

The ethnic density variables were assessed in models stratified by ethnicity. The aim was to determine if 'own ethnic density' was associated with body size. For example, analysis examined whether White UK density was associated with body size for White UK pupils, Black Caribbean density for Black Caribbean pupils etc. As previously described, quartiles of the ethnic density variables were used. Additional analyses then assessed the impact of non-White UK density on body size; quartiles of this variable were set to the overall sample. This variable was used first in models of the overall sample, and then an interaction between non-White UK density and ethnicity was fitted in order to determine if the impact of the proportion of non White UK residents in a neighbourhood had a differential effect on body size by ethnic group. Findings for residential neighbourhood are illustrated in Figure 5.14 and results presented in full for residential neighbourhood in Table 5.17 and school neighbourhood in Table 5.18.

For boys, the only significant association between own ethnic group density and body size was for Waist SDS for White UK boys; compared to those living in Q1 (lowest density White UK residents) those living in Q4 had significantly lower Waist SD scores. Although there was no significant difference between those in Q2 or Q3 compared to those in Q1, a trend was discernible (Figure 5.14). A similar trend was observed for BMI SDS for the White UK boys. For girls, higher Black African density in the residential neighbourhood was associated with a higher mean BMI SD score for Nigerian/Ghanaian girls; the results for Waist SDS did not reach statistical significance but SD scores were higher in Q2, Q3 and Q4 relative to Q1. Compared to Pakistani/Bangladeshi boys attending schools in low own density areas, those in higher density areas tended to have a lower mean BMI SDS, significant for those in Q3. There were no other significant associations between own ethnic density in the school neighbourhood and body size for boys or girls.

The proportion of non-White UK people in the residential neighbourhoods was not associated with BMI SDS or Waist SDS for either boys or girls, and interactions with ethnicity were not significant. The proportion of non-White UK residents in the schools' neighbourhoods was not associated with either body size measure for boys or girls in the overall samples, however the interaction with ethnicity was significant for BMI SDS for girls ($p<0.05$). Analysis stratified by ethnicity revealed that non-White UK school neighbourhood density was a significant correlate only for Other African girls; high ethnic minority density was associated with a lower mean BMI for Other African girls. Compared to those in Q1 (schools in neighbourhoods with the lowest proportion of non-White UK residents) those in Q2 (-0.26, -0.82 to 0.30), Q3 (-0.63, -1.15 to -0.11) and Q4 (-0.55, -1.08 to -0.02) had lower BMI SD scores, significantly so for those in Q3 and Q4.

Figure 5.14 Relationship between residential neighbourhood own ethnic density and body size

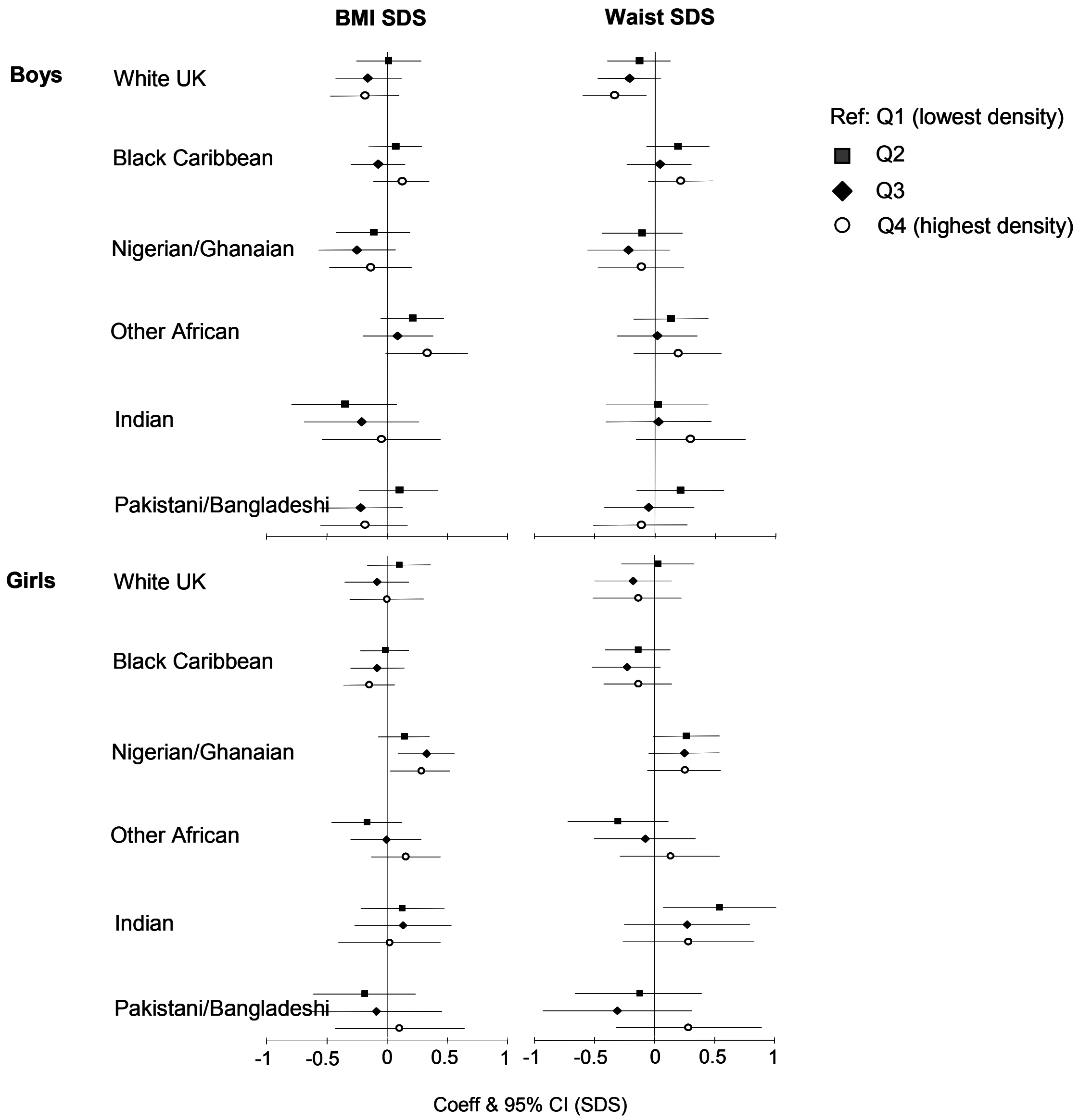


Table 5.17 Residential neighbourhood ethnic density and body size by gender

		Boys		Girls	
		BMI SDS	Waist SDS	BMI SDS	Waist SDS
White UK	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	0.01 (-0.25-0.28)	-0.13 (-0.39-0.13)	0.10 (-0.16-0.36)	0.03 (-0.28-0.33)
	Q3	-0.16 (-0.43-0.12)	-0.21 (-0.47-0.05)	-0.08 (-0.35-0.18)	-0.18 (-0.50-0.14)
	Q4	-0.19 (-0.47-0.10)	-0.34 (-0.60- -0.07)*	-0.01 (-0.31-0.30)	-0.14 (-0.51-0.22)
Black Caribbean	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	0.07 (-0.15-0.29)	0.19 (-0.07-0.45)	-0.02 (-0.22-0.18)	-0.14 (-0.41-0.13)
	Q3	-0.07 (-0.30-0.15)	0.04 (-0.23-0.30)	-0.08 (-0.30-0.14)	-0.23 (-0.52-0.05)
	Q4	0.12 (-0.11-0.35)	0.21 (-0.06-0.48)	-0.15 (-0.36-0.06)	-0.14 (-0.42-0.14)
Nigerian/Ghanaian	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	-0.11 (-0.42-0.19)	-0.11 (-0.44-0.23)	0.14 (-0.07-0.35)	0.26 (-0.01-0.54)
	Q3	-0.25 (-0.57-0.07)	-0.22 (-0.56-0.12)	0.33 (0.09-0.56)*	0.25 (-0.05-0.54)
	Q4	-0.14 (-0.48-0.20)	-0.12 (-0.47-0.24)	0.28 (0.03-0.52)*	0.25 (-0.06-0.55)
Other African	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	0.21 (-0.05-0.47)	0.13 (-0.18-0.44)	-0.17 (-0.46-0.12)	-0.31 (-0.72-0.11)
	Q3	0.09 (-0.20-0.38)	0.02 (-0.31-0.35)	-0.01 (-0.30-0.28)	-0.08 (-0.50-0.34)
	Q4	0.33 (-0.01-0.67)	0.19 (-0.17-0.55)	0.15 (-0.13-0.44)	0.13 (-0.29-0.54)
Indian	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	-0.35 (-0.79-0.08)	0.02 (-0.41-0.44)	0.12 (-0.22-0.47)	0.54 (0.07-1.01)
	Q3	-0.21 (-0.69-0.26)	0.03 (-0.41-0.47)	0.13 (-0.27-0.53)	0.27 (-0.25-0.79)
	Q4	-0.05 (-0.54-0.44)	0.29 (-0.16-0.75)	0.02 (-0.40-0.44)	0.28 (-0.26-0.83)
Pakistani/ Bangladeshi	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	0.10 (-0.23-0.42)	0.21 (-0.15-0.57)	-0.19 (-0.61-0.23)	-0.13 (-0.66-0.39)
	Q3	-0.22 (-0.56-0.13)	-0.05 (-0.42-0.32)	-0.09 (-0.62-0.45)	-0.31 (-0.93-0.31)
	Q4	-0.19 (-0.55-0.17)	-0.12 (-0.51-0.27)	0.10 (-0.43-0.64)	0.28 (-0.32-0.89)
Non-White UK	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	0.06 (-0.06-0.18)	0.06 (-0.07-0.19)	0.04 (-0.07-0.15)	0.12 (-0.03-0.26)
	Q3	0.10 (-0.03-0.23)	0.11 (-0.03-0.25)	0.02 (-0.10-0.14)	0.05 (-0.10-0.21)
	Q4	-0.01 (-0.16-0.13)	0.02 (-0.14-0.17)	-0.00 (-0.13-0.13)	0.12 (-0.05-0.29)

*Significantly different to reference category ($p<0.05$)

Table 5.18 School neighbourhood ethnic density and body size by gender

		Boys		Girls	
		BMI SDS	Waist SDS	BMI SDS	Waist SDS
White UK	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	-0.11 (-0.45-0.24)	-0.20 (-0.48-0.09)	-0.06 (-0.42-0.31)	-0.10 (-0.50-0.31)
	Q3	-0.12 (-0.47-0.23)	-0.08 (-0.36-0.21)	-0.28 (-0.67-0.12)	-0.34 (-0.78-0.10)
	Q4	-0.09 (-0.46-0.28)	-0.20 (-0.49-0.10)	-0.35 (-0.79-0.10)	-0.47 (-0.97-0.04)
Black Caribbean	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	0.10 (-0.23-0.43)	0.20 (-0.13-0.53)	0.12 (-0.27 (0.50)	0.08 (-0.29-0.45)
	Q3	0.09 (-0.25-0.42)	0.05 (-0.29-0.39)	-0.07 (-0.48-0.33)	0.05 (-0.34-0.44)
	Q4	0.20 (-0.12-0.53)	0.25 (-0.09-0.59)	-0.25 (-0.66-0.15)	-0.35 (-0.73-0.04)
Nigerian/Ghanaian	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	0.29 (-0.14-0.72)	0.30 (-0.09-0.69)	0.03 (-0.30-0.36)	-0.11 (-0.44-0.22)
	Q3	0.19 (-0.21-0.58)	0.15 (-0.21-0.51)	0.16 (-0.24-0.56)	0.33 (-0.07-0.73)
	Q4	0.32 (-0.08-0.73)	0.11 (-0.27-0.47)	0.01 (-0.32-0.34)	0.15 (-0.19-0.48)
Other African	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	-0.43 (-0.88-0.03)	-0.35 (-0.80-0.11)	-0.29 (-0.75-0.17)	-0.12 (-0.60-0.37)
	Q3	-0.22 (-0.67-0.23)	-0.01 (-0.48-0.47)	-0.05 (-0.52-0.42)	-0.14 (-0.63-0.35)
	Q4	-0.15 (-0.61-0.31)	-0.23 (-0.69-0.23)	-0.04 (-0.53-0.45)	-0.16 (-0.66-0.35)
Indian	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	-0.24 (-0.79-0.32)	-0.07 (-0.57-0.43)	-0.17 (-0.63-0.30)	-0.09 (-0.63-0.46)
	Q3	-0.09 (-0.62-0.44)	0.11 (-0.38-0.60)	-0.81 (-1.63-0.01)	-0.83 (-1.79-0.13)
	Q4	0.24 (-0.33-0.81)	0.12 (-0.40-0.63)	-0.08 (-0.61-0.45)	-0.22 (-0.83-0.39)
Pakistani/ Bangladeshi	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	-0.26 (-0.65-0.13)	-0.24 (-0.64-0.17)	-0.23 (-0.78-0.32)	-0.26 (-0.85-0.34)
	Q3	-0.59 (-1.12- -0.07)*	-0.48 (-1.01-0.04)	-0.23 (-1.06-0.59)	-0.04 (-0.96-0.88)
	Q4	-0.29 (-0.74-0.16)	-0.16 (-0.63-0.31)	-0.21 (-0.82-0.41)	-0.28 (-0.95-0.38)
Non-White UK	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	0.03 (-0.15-0.22)	-0.02 (-0.23-0.18)	0.07 (-0.15-0.28)	0.21 (-0.04-0.46)
	Q3	-0.07 (-0.26-0.12)	0.00 (-0.21-0.21)	0.02 (-0.19-0.23)	0.15 (-0.09-0.40)
	Q4	0.03 (-0.17-0.23)	0.08 (-0.14-0.30)	-0.01 (-0.23-0.21)	0.02 (-0.24-0.28)

*Significantly different to reference category (p<0.05)

The proportion of variation in BMI SDS and Waist SDS explained by non-White UK residential neighbourhood density was small (Table 5.19). School neighbourhood non-White density explained 25% of the between school variance in BMI SDS for girls but increased between school variance for the boys by a similar proportion (Table 5.19). The impact on school-level variation for Waist SDS was less.

Table 5.19: Proportion of BMI SDS and Waist SDS variance explained by neighbourhood non-White UK ethnic density

	BMI SDS Variance (Baseline)	% variance explained	**Waist SDS** Variance (Baseline)	% variance explained
Residential				
Boys				
School	0.006	-6.98	0.022	-2.60
Individual	1.517	0.14	1.055	0.24
Measurement	0.239	-0.05	0.479	-0.15
Total	1.762	0.09	1.556	0.08
Girls				
School	0.015	1.90	0.036	3.71
Individual	1.317	-0.09	1.245	-0.21
Measurement	0.186	-0.08	0.504	0.13
Total	1.517	-0.07	1.785	-0.04
School				
Boys				
School	0.006	-26.26	0.022	-11.15
Individual	1.517	-0.01	1.055	-0.01
Measurement	0.239	0.00	0.479	-0.01
Total	1.762	-0.10	1.556	-0.17
Girls				
School	0.015	25.35	0.036	2.27
Individual	1.317	0.32	1.245	0.02
Measurement	0.186	0.03	0.504	0.01
Total	1.517	0.52	1.785	0.07

5.3.2 Deprivation and crime and body size

There were few significant results but BMI and Waist coefficients tended to be positive for deprivation for both boys and girls, but significant only for some Waist SDS quintiles for girls (Table 5.20). Broadly speaking this could be taken to indicate larger waists in deprived versus least deprived areas. For crime there were inconsistencies in the results for school and residential neighbourhoods and by body size measure. Compared to those attending schools in the lowest crime areas, boys and girls in schools in higher crime areas had significantly larger waists in overall analysis, and interactions with ethnicity were also significant for both sexes (boys $p<0.05$; girls $p<0.001$).

In models stratified by ethnicity, school neighbourhood crime was a significant correlate for White UK and Indian boys, and White UK, Black Caribbean and Nigerian/Ghanaian girls. For White UK boys and girls, there was a suggestion of a trend; increasing crime in the schools' neighbourhoods being associated with an increase in Waist SD score. For White UK boys those attending school in crime Q3 (0.56, 0.26 to 0.87), Q4 (0.63, 0.29 to 0.97) and Q5 (0.73, 0.37 to 1.09) had significantly higher SD scores than those attending a school located in Q2 (lowest crime levels as no schools in Q1). For White UK girls, those in schools in the highest crime areas (Q5) had SD scores 0.54 (0.10 to 0.98) higher than those in schools in the lowest crime areas (Q2). Those in Q3 and Q4 also had higher scores but not significantly so. Similar trends were observed for the Black Caribbean girls [Q3 (2.29, 0.49 to 4.08), Q4 (2.59, 0.79 to 4.40) and Q5 (2.68, 0.88 to 4.48)] and Nigerian/Ghanaian girls [Q4 (0.43, 0.15 to 0.71) and Q5 (0.52, 0.26 to 0.78), there were no Nigerian/Ghanaian girls attending a school in crime Q3]. In contrast, for Indian boys those in Q5 had significantly lower SD scores than those in Q2 (-0.33, -0.56 to -0.10); there were no other significant ethnic differences.

The relationship between BMI SDS and crime was non-significant for both boys and girls, however the interaction with ethnicity was significant for girls for school neighbourhood crime ($p<0.05$). Further analysis revealed the association was only significant for White UK girls; as with Waist SDS, those attending schools in higher crime areas had higher BMI SD scores.

Table 5.20 Neighbourhood deprivation and crime and body size

		Boys BMI SDS	Boys Waist SDS	Girls BMI SDS	Girls Waist SDS
Residential					
Deprivation	Q1 (least deprived)	Ref	Ref	Ref	Ref
	Q2	0.19 (-0.16-0.54)	0.13 (-0.30-0.55)	0.27 (-0.02-0.56)	0.56 (0.15 - 0.98)*
	Q3	0.22 (-0.12-0.56)	0.11 (-0.30-0.51)	0.20 (-0.08-0.47)	0.39 (-0.00 - 0.79)
	Q4	0.21 (-0.13-0.55)	0.15 (-0.24-0.55)	0.25 (-0.03-0.53)	0.51 (0.12 – 0.90)*
	Q5	0.19 (-0.15-0.53)	0.16 (-0.23-0.56)	0.27 (-0.01-0.55)	0.58 (0.19 – 0.98)*
Crime	Q1 (lowest crime)	Ref	Ref	Ref	Ref
	Q2	-0.19 (-0.48-0.10)	-0.20 (-0.57-0.17)	-0.29 (-0.58-0.00)	-0.28 (-0.70 - 0.14)
	Q3	-0.12 (-0.42-0.17)	-0.07 (-0.44-0.29)	-0.28 (-0.57-0.01)	-0.31 (-0.73 - 0.11)
	Q4	-0.14 (-0.44-0.15)	-0.10 (-0.48-0.27)	-0.19 (-0.48-0.10)	-0.14 (-0.55 – 0.28)
	Q5	-0.19 (-0.49-0.11)	-0.12 (-0.49-0.26)	-0.22 (-0.51-0.08)	-0.20 (-0.62 – 0.22)
School					
Deprivation	Q1 (least deprived)	Ref	Ref	Ref	Ref
	Q2	0.09 (-0.41-0.60)	0.44 (-0.13-1.02)	0.25 (-0.26-0.75)	0.54 (-0.09-1.17)
	Q3	0.24 (-0.22-0.71)	0.46 (-0.05-0.97)	0.15 (-0.32-0.63)	0.63 (0.07-1.19)*
	Q4	0.17 (-0.30-0.63)	0.25 (-0.25-0.76)	0.15 (-0.32-0.62)	0.48 (-0.07-1.03)
	Q5	0.20 (-0.26-0.67)	0.32 (-0.19-0.83)	0.24 (-0.23-0.71)	0.69 (0.13-1.14)*
Crime	Q1 (lowest crime)	Ref	Ref^	Ref^	Ref^
	Q2	/	/	/	/
	Q3	0.05 (-0.18-0.28)	0.50 (0.19-0.82)*	0.00 (-0.20-0.21)	0.30 (-0.03-0.63)
	Q4	0.03 (-0.22-0.27)	0.59 (0.25-0.92)*	0.07 (-0.15-0.29)	0.64 (0.29-0.99)*
	Q5	-0.01 (-0.25-0.24)	0.52 (0.18-0.86)*	0.08 (-0.14-0.30)	0.59 (0.24-0.94)*

*Significantly different to reference category ($p<0.05$)

^ Significant interaction between variable and ethnicity: School neighbourhood Crime: Boys Waist SDS p=0.031; Girls BMI SDS p=0.012; Girls Waist SDS p<0.00005. full details in text.

The deprivation and crime variables explained very little (<1%) of the total variance in either body size measure (BMI Table 5.21; Waist Table 5.22). School neighbourhood deprivation explained 13% of the girls' between school variance in BMI SDS. However in interpreting this figure it is important to emphasise the extremely small amount of variance at the school level and therefore the very small absolute amount of variance that is being explained by this measure. School neighbourhood deprivation and crime had a larger effect on between school variability for Waist SDS than BMI SDS; both of these variables increased between school variance by over 16% for the boys, and IMD decreased school level variance by almost 16% for the girls, and crime by over 4%.

Table 5.21: Proportion BMI SDS variance explained by neighbourhood IMD and Crime

	Variance (baseline)	% variance explained by each model IMD	 Crime
Residential			
Boys			
School	0.006	2.93	-0.20
Individual	1.517	-0.08	0.11
Measurement	0.239	-0.05	-0.05
Total	1.762	-0.06	0.08
Girls			
School	0.015	4.49	-2.94
Individual	1.317	-0.14	-0.14
Measurement	0.186	0.16	0.48
Total	1.517	-0.06	-0.09
School			
Boys			
School	0.006	-3.28	1.72
Individual	1.517	0.01	-0.03
Measurement	0.239	0.16	-0.06
Total	1.762	0.02	-0.03
Girls			
School	0.015	13.49	-2.55
Individual	1.317	0.04	-0.17
Measurement	0.186	0.04	0.98
Total	1.517	0.17	-0.05

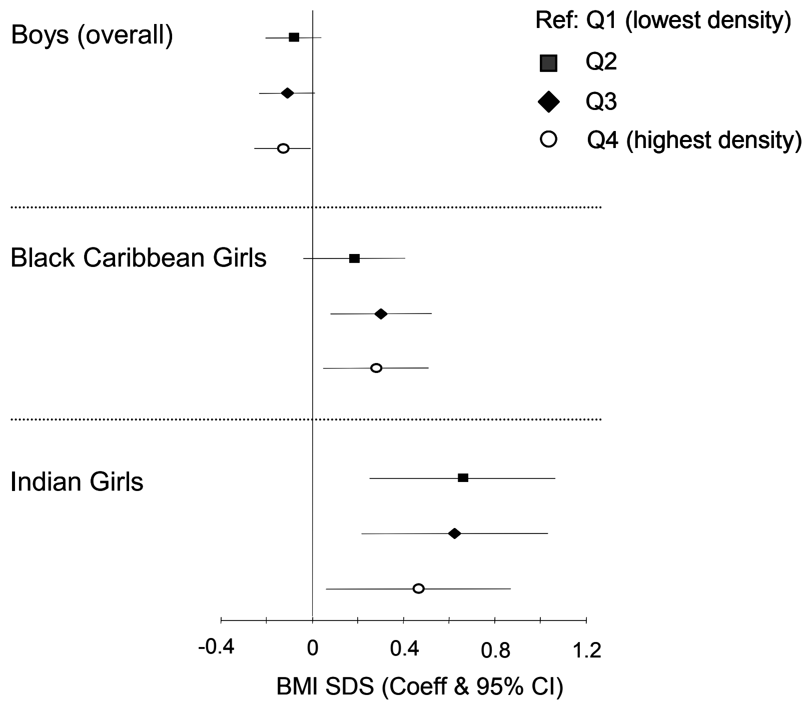
Table 5.22: Proportion of Waist SDS variance explained by neighbourhood IMD and Crime

	Variance (baseline)	% variance explained by each model IMD	 Crime
Residential			
Boys			
School	0.022	-1.03	-1.12
Individual	1.055	-0.07	0.03
Measurement	0.479	-0.07	-0.05
Total	1.556	-0.09	-0.01
Girls			
School	0.036	15.62	1.06
Individual	1.245	-0.62	-0.18
Measurement	0.504	0.80	0.50
Total	1.785	0.11	0.04
School			
Boys			
School	0.022	-16.33	-16.53
Individual	1.055	-0.13	-0.09
Measurement	0.479	0.83	1.13
Total	1.556	-0.06	0.05
Girls			
School	0.036	15.91	4.34
Individual	1.245	-0.21	-0.55
Measurement	0.504	0.94	3.72
Total	1.785	0.45	0.75

5.3.3 Land Use and body size

For each land use variable (domestic buildings, non-domestic buildings, roads, green space, and domestic buildings) quartile 1 (lowest proportion of land use) was the reference category. There was only one significant relationship between a residential neighbourhood land use and body size; boys in neighbourhoods with the highest proportion of domestic gardens (Q4) had significantly lower BMI SD scores than those in neighbourhoods with the least (-0.13, -0.26 to -0.01). There was a suggestion of a slight trend; an increasing proportion of domestic gardens being associated with a decrease in BMI SDS (Figure 5.15). There was no overall association with BMI SDS for girls but there was a significant interaction with ethnicity (p=0.0190); in stratified analysis the proportion of domestic gardens was significantly associated with BMI SDS for the Black Caribbean and Indian girls. Black Caribbeans in Q3 and Q4, and Indians in Q2, Q3 and Q4, had significantly higher BMI SD scores than those in Q1; therefore the direction of association was the opposite to that observed for the boys (Figure 5.15). (The other residential land use results are summarised in Table 8.2 in the Appendix).

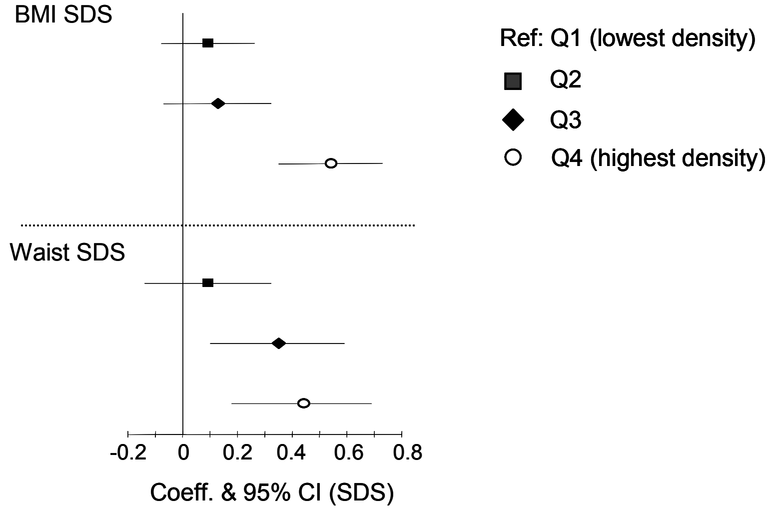
Figure 5.15: Residential Neighbourhood Domestic Gardens density and BMI SDS



Residential road density was not associated with body size in overall analyses but the interaction with ethnicity was significant for boys for both body size measures (BMI SDS p<0.01; Waist SDS p=<0.05). Stratified analysis showed that the association between road density and body size was significant for Black Caribbean boys only (Figure 5.16).

Compared to those in Q1 (lowest road density) those in Q4 had significantly higher BMI SD scores; 0.38 (0.18 to 0.58), p<0.001. Those in quartiles 2 and 3 also had higher BMI SD scores than those in Q1 but the difference was not significant. Similarly, for Waist SDS Black Caribbean boys in Q3 (0.35, 0.10 to 0.59, p=0.006) and Q4 (0.44, 0.18 to 0.69, p=0.001) had significantly higher scores than those in Q1.

Figure 5.16: Black Caribbean boys: residential road density and body size



There was also a significant interaction with ethnicity for residential neighbourhood non-domestic buildings for girls for BMI SDS (p<0.01). However in analysis stratified by ethnicity there was no suggestion that an increasing proportion of non-domestic buildings was associated with change in BMI for any ethnic group.

There were significant associations for school neighbourhood green space, roads, and domestic buildings for girls (although there were also significant results for boys in Q2 for green space and roads there were no trends) (Table 5.23). Girls attending schools in 'greener' neighbourhoods had smaller waists than those in schools the least green areas; girls in schools in areas with a higher proportion of roads had higher BMIs than those in areas with the lowest proportion of roads; and girls attending school in areas with the most domestic buildings had significantly higher BMIs than those in schools in areas with the least. Domestic building density was not associated with Waist SDS in overall analysis for girls, but the interaction with ethnicity was significant (p=0.047). Compared to those in Q1, Indians in schools in Q3 (0.75, 0.13 to 1.37) and Pakistani/Bangladeshis in Q4 (0.76, 0.09 to 1.42) had significantly larger waists. As with residential areas, there was a significant interaction between school neighbourhood domestic gardens and ethnicity for BMI SDS for girls (p=0.01). For the Indians, those in Q2 (0.75, 0.19 to1.30) and those in

Q4 (0.51, 0.03 to 0.99) had significantly higher scores than those in Q1 (lowest proportion of domestic gardens). Those in Q3 also had higher scores, but not significantly so (0.40, -0.15 to 0.96). Therefore the pattern of more domestic gardens being associated with higher BMI for Indian girls was found for both school and residential areas. For the Pakistani/Bangladeshi girls, those in Q2, Q3, and Q4 also had higher scores than those in Q1 but this was significant only for Q3; 0.77 (0.22 to1.32).

Table 5.23 School neighbourhood land use and body size

		Boys		Girls	
		BMI SDS	Waist SDS	BMI SDS	Waist SDS
Domestic Buildings	Q1 (lowest density)	Ref	Ref	Ref	Ref^
	Q2	-0.09 (-0.22-0.04)	-0.21 (-0.38- -0.05)*	0.03 (-0.09-0.16)	-0.07 (-0.26-0.12)
	Q3	-0.10 (-0.26-0.05)	-0.12 (-0.30-0.07)	0.03 (-0.14-0.21)	-0.02 (-0.25-0.22)
	Q4	-0.07 (-0.22-0.08)	-0.15 (-0.34-0.05)	0.20 (0.03-0.37)*	0.16 (-0.07-0.39)
Non-domestic buildings	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	-0.08 (-0.20-0.04)	-0.03 (-0.18-0.12)	0.04 (-0.09-0.17)	0.04 (-0.13-0.22)
	Q3	0.01 (-0.12-0.14)	0.05 (-0.12-0.21)	-0.02 (-0.17-0.12)	0.08 (-0.12-0.27)
	Q4	0.06 (-0.08-0.20)	0.00 (-0.18-0.18)	0.09 (-0.12-0.30)	0.10 (-0.15-0.34)
Roads	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	-0.03 (-0.14-0.07)	-0.18 (-0.31- -0.05)*	0.12 (0.01-0.22)*	0.08 (-0.07-0.24)
	Q3	-0.02 (-0.15-0.11)	-0.09 (-0.25-0.08)	0.13 (-0.02-0.28)	0.06 (-0.13-0.26)
	Q4	-0.01 (-0.16-0.14)	-0.05 (-0.24-0.13)	0.18 (0.03-0.34)*	0.15 (-0.05-0.36)
Green Space	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	0.01 (-0.10-0.11)	-0.23 (-0.36- -0.09)*	0.01 (-0.13-0.15)	-0.10 (-0.29-0.10)
	Q3	-0.06 (-0.23-0.11)	-0.05 (-0.24-0.13)	-0.21 (-0.39- -0.04)*	-0.26 (-0.49- -0.03)*
	Q4	0.04 (-0.12-0.21)	-0.02 (-0.20-0.16)	-0.16 (-0.35-0.02)	-0.24 (-0.47- -0.01)*
Domestic Gardens	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	-0.10 (-0.25-0.05)	-0.03 (-0.21-0.16)	0.12 (-0.07-0.31)	0.16 (-0.08-0.40)
	Q3	-0.11 (-0.25-0.04)	-0.03 (-0.21-0.16)	0.12 (-0.06-0.31)	0.22 (-0.02-0.45)
	Q4	-0.10 (-0.26-0.05)	0.02 (-0.17-0.21)	0.05 (-0.14-0.24)	0.03 (-0.21-0.27)

*Significantly different to reference category ($p<0.05$)

^Significant interaction with ethnicity p=0.047

For BMI SDS, residential neighbourhood non-domestic buildings, roads and domestic gardens explained relatively large proportions of between school variance (15%, 17% and 24% respectively). They had a much smaller impact on individual and measurement variance, and on girls' variance compared to boys' (Table 5.24). For Waist SDS, the proportion of school level variance explained by the residential land use variables was generally smaller than that observed for BMI SDS (Table 5.25).

Considering there was little significant association between school neighbourhood land use and BMI SDS for boys, some variables account for a surprisingly large proportion of between school variance (e.g. 95% for non-domestic buildings). For girls, green space and domestic buildings account for large proportions of between school variation (51% and

41% respectively). In contrast, for Waist SDS, adjustment for the school neighbourhood land use variables generally increased between school variance (the exception being green space for boys, and roads and green space for girls). Road explained almost 15% and green space almost 20% of between school variance in Waist SDS for girls; less than the proportions seen for BMI SDS.

Table 5.24: Proportion of BMI SDS variance explained by neighbourhood land use

	Variance (Baseline)	% variance explained by each model Domestic	Non-domestic	Roads	Green	Gardens
Residential						
Boys						
School	0.006	0.09	14.58	16.83	-3.47	23.59
Individual	1.517	-0.05	-0.12	0.03	-0.02	-0.05
Measurement	0.239	-0.10	-0.02	0.88	-0.01	0.08
Total	1.762	-0.05	-0.06	0.20	-0.03	0.04
Girls						
School	0.015	-0.05	-7.18	0.29	0.78	3.65
Individual	1.317	-0.10	0.58	-0.05	0.03	0.17
Measurement	0.186	0.02	0.61	-0.07	-0.06	0.57
Total	1.517	-0.09	0.51	-0.05	0.02	0.25
School						
Boys						
School	0.006	32.90	95.03	-5.91	-6.54	36.86
Individual	1.517	-0.07	-0.11	-0.01	-0.04	-0.07
Measurement	0.239	-0.04	-0.05	-0.10	-0.04	-0.08
Total	1.762	0.04	0.21	-0.04	-0.06	0.05
Girls						
School	0.015	40.81	-24.76	31.81	51.37	-24.60
Individual	1.317	0.00	0.00	-0.08	-0.06	0.40
Measurement	0.186	-0.03	0.11	0.10	-0.02	0.62
Total	1.517	0.39	-0.23	0.25	0.44	0.19

Table 5.25: Proportion of Waist SDS variance explained by neighbourhood land use

	Variance (Baseline)	% variance explained by each model Domestic	Non-domestic	Roads	Green	Gardens
Residential						
Boys						
School	0.022	0.80	0.97	-4.98	2.97	0.15
Individual	1.055	-0.16	-0.07	0.15	-0.08	-0.10
Measurement	0.479	0.05	-0.04	0.60	0.08	0.10
Total	1.556	-0.08	-0.05	0.21	0.01	-0.04
Girls						
School	0.036	3.02	0.24	3.34	0.84	0.24
Individual	1.245	-0.43	-0.21	-0.11	0.06	0.00
Measurement	0.504	0.32	0.04	-0.01	-0.12	-0.12
Total	1.785	-0.15	-0.13	-0.01	0.03	-0.03
School						
Boys						
School	0.022	-21.23	-14.65	-18.75	1.87	-14.95
Individual	1.055	-0.26	-0.04	-0.21	-0.13	-0.09
Measurement	0.479	0.48	0.07	0.47	0.44	0.33
Total	1.556	-0.33	-0.22	-0.27	0.07	-0.17
Girls						
School	0.036	-27.39	-0.26	14.86	19.95	-16.37
Individual	1.245	0.61	-0.02	-0.02	-0.11	-0.20
Measurement	0.504	0.45	-0.10	-0.16	0.05	0.38
Total	1.785	-0.01	-0.05	0.25	0.35	-0.37

5.3.4 Subjective opinion of neighbourhood of residence and body size

The four neighbourhood items from the DASH questionnaire (like area, safe in area during day, safe in area at night, good area) were added to the baseline models individually in binary form (strongly agree/agree versus disagree/strongly disagree). For both boys and girls, none of the items were significantly associated with either BMI SDS or Waist SDS, and there were no significant interactions with ethnicity (Table 5.26). The neighbourhood perceptions variables had little impact on BMI or Waist variance at any level of the girls' or boys' models (Table 5.27).

Table 5.26 Subjective neighbourhood and body size

		Boys		Girls	
		BMI SDS	Waist SDS	BMI SDS	Waist SDS
Like area	Agree/Strongly agree	Ref	Ref	Ref	Ref
	Disagree/Strongly Disagree	0.03 (-0.04-0.10)	-0.05 (-0.14-0.04)	-0.04 (-0.10-0.02)	0.02 (-0.08-0.11)
Safe during day	Agree/Strongly agree	Ref	Ref	Ref	Ref
	Disagree/Strongly Disagree	0.04 (-0.02-0.11)	-0.01 (-0.09-0.08)	-0.00 (-0.07-0.06)	0.09 (-0.00-0.19)
Safe at night	Agree/Strongly agree	Ref	Ref	Ref	Ref
	Disagree/Strongly Disagree	0.01 (-0.04-0.06)	-0.02 (-0.09-0.04)	0.01 (-0.04-0.06)	0.03 (-0.04-0.10)
Good reputation	Agree/Strongly agree	Ref	Ref	Ref	Ref
	Disagree/Strongly Disagree	0.01 (-0.05-0.06)	-0.03 (-0.11-0.04)	-0.04 (-0.09-0.02)	-0.01 (-0.09-0.07)

Table 5.27: Proportion of BMI SDS variance explained by neighbourhood perceptions

		% variance explained by each model			
	Variance (Baseline)	Like Area	Good Area	Safe Day	Safe Night
BMI SDS					
Boys					
School	0.006	-0.67	-0.44	-3.06	-1.52
Individual	1.517	-0.02	-0.02	0.00	-0.02
Measurement	0.239	0.00	-0.03	0.05	-0.02
Total	1.762	-0.02	-0.02	0.00	-0.03
Girls					
School	0.015	0.11	-4.50	0.07	0.81
Individual	1.317	-0.08	-0.05	-0.02	-0.01
Measurement	0.186	0.10	0.12	-0.04	-0.04
Total	1.517	-0.06	-0.07	-0.02	0.00
Waist SDS					
Boys					
School	0.006	1.01	1.05	0.12	0.94
Individual	1.517	-0.04	0.04	-0.01	-0.01
Measurement	0.239	0.02	-0.04	-0.04	-0.02
Total	1.762	-0.01	0.03	-0.02	0.00
Girls					
School	0.015	0.34	-0.86	0.50	2.28
Individual	1.317	0.01	-0.03	0.29	-0.05
Measurement	0.186	-0.06	-0.02	-0.06	-0.01
Total	1.517	0.00	-0.04	0.19	0.01

5.3.5 *Interactions with age*

All of the models presented so far have assumed that any association between the neighbourhood variables and the body size measures was independent of age. However it is possible that neighbourhood effects could emerge or diminish with increasing age. To test this, models were rerun including an interaction term between each of the neighbourhood terms and wave. Significant interactions are summarised in Table 5.28. There were more significant interactions between school neighbourhood and wave than residential neighbourhood and wave, and more for Waist SDS than BMI SDS.

For White UK boys, there was a significant interaction between wave and White UK ethnic density for BMI SDS. At W2, White UK boys living in neighbourhoods with higher proportions of White UK residents had significantly lower BMI SD scores than those in areas with low proportions of White UK residents; in contrast, at W1 ethnic density was not a significant correlate, although the direction of effect was the same.

For both boys and girls, there was a significant interaction between school neighbourhood deprivation and Waist SDS, and the pattern was identical for both genders. At both waves, relative to those attending school in the least deprived areas, those attending schools in more deprived areas had higher Waist SD scores, however the difference was larger at 11-13yrs than 14-16yrs (and not significant at either age). A similar pattern was observed for school neighbourhood crime.

For girls' Waist SDS, the interaction between wave and own school neighbourhood ethnic density was significant for every ethnic group, however there was no clear pattern. Those in Q2 and Q3 of Non-White UK density had significantly higher Waist SD scores than those in Q1 (lowest proportion Non-White UK) at 11-13yrs but not at 14-16yrs. However those in Q4 had smaller waists at 11-13yrs; therefore there was no linear trend across the quintiles.

There were several significant interactions between school neighbourhood land use types and wave for Waist SDS, however there were few consistent patterns. Of note is the interaction between gardens and Waist SDS for girls. Compared to those in schools surrounded by the lowest proportion of gardens, those attending schools in the other quartiles had higher Waist SD scores at 11-13yrs, but no differences were statistically significant. However by 14-16yrs, the difference between those in Q1 and each of the other quartiles had increased, with the difference becoming statistically significant for those in Q2.

Table 5.28 Summary of interactions between neighbourhood variables and wave

Key to table:

Variables only included in table if interaction with wave was significant for at least one gender/body size measure.

Empty cell if interaction was not significant (p>=0.05)

Filled cells contain p-value of interaction term (wave*variable)

First symbol indicates if effect of variable was positive (+) or negative (-) at W1

Second symbol indicates if effect of variable was + or – at W2.

* beside a direction of effect symbol (+ or -) indicates that the variable was significantly associated with the outcome at that wave.

If direction of effect the same at both waves, a third symbol is given which indicates whether the effect size is larger (▲) or smaller (▼) at W2 compared to W1.

Therefore if the effect at W1 was -0.3 (not significant) and at W2 -0.6 (significant) then the code would be - -* ▲.

/ Where there is no result for that Wave (e.g. if no school in that quartile)

		Boys		Girls	
		BMI SDS	Waist SDS	BMI SDS	Waist SDS
Residential Neighbourhood					
Ethnic Density					
White UK		P=0.028			
	Q1 (Ref)				
	Q2	- - ▲			
	Q3	- -* ▲			
	Q4	- -* ▲			
Non-White UK					P=0.016
	Q1 (Ref)				
	Q2				+ -
	Q3				+ -
	Q4				+ + ▼
School Neighbourhood					
Deprivation			P=0.0005		P<0.00005
	Q1				
	Q2(Ref, most affluent)		/ +		/ +
	Q3		+ + ▼		+ + ▼
	Q4		+ + ▼		+ + ▼
	Q5		+ + ▼		+ + ▼
Crime			P=0.0002		P=0.0002
	Q2 (Ref, lowest crime)				
	Q3		+ -		+ /
	Q4		+ /		+ -
	Q5		+ + ▼		+ + ▼
Own Ethnic Density					
White UK					P=0.0042
	Q1 (Ref)				
	Q2				+ -
	Q3				- - ▼
	Q4				- - ▼
Nigerian/Ghanaian					P=0.0044
	Q1 (Ref)				
	Q2				- - ▲
	Q3				+ + ▼
	Q4				+ + ▲
Other African					P=0.0067
	Q1 (Ref)				
	Q2				+ -
	Q3				+ -
	Q4				- - ▼

Indian		P=0.0001	P<0.00005
	Q1 (Ref)		
	Q2	+ -	+ -
	Q3	+ -	- - ▲
	Q4	+ + ▲	- +
Pakistani/Bangladeshi		P=0.0077	P=0.0019
	Q1 (Ref)		
	Q2	- - ▼	- - ▲
	Q3	-* - ▼	- +
	Q4	- - ▼	+ -
Non White UK			P<0.00005
	Q1 (Ref)		
	Q2		+* + ▼
	Q3		+* + ▼
	Q4		- +
Land Use			
Domestic Buildings		P<0.00005	
	Q1 (Ref: smallest		
	proportion)	- - ▲	
	Q2	- +	
	Q3	- +	
	Q4		
Non domestic buildings		P<0.00005	
	Q1 (Ref: smallest		
	proportion)	+ -	
	Q2	+ -	
	Q3	- +	
	Q4		
Roads		P<0.00005	P=0.0259
	Q1 (Ref: smallest		
	proportion)	- - ▲	+ + ▼
	Q2	- +	+ + ▼
	Q3	- +	+ + ▲
	Q4		
Green Space		P=0.0009	P=0.0001
	Q1 (Ref: smallest		
	proportion)	- - ▼	+ -
	Q2	+ -	- - ▼
	Q3	- - ▲	- - ▲
	Q4		
Gardens		P=0.0247	P=0.0472
	Q1 (Ref: smallest		
	proportion)	- - ▲	+ +* ▲
	Q2	- - ▼	+ + ▲
	Q3	+ -	+ + ▲
	Q4		

5.3.6 Key Findings - neighbourhoods and body size

- Greater residential neighbourhood own ethnic density was associated with a decrease in body size for White UK boys and an increase for Nigerian/Ghanaian girls. Greater school neighbourhood non-White UK ethnic density was associated with a decrease in BMI for Other African girls.

- Girls who lived or attended school in more deprived areas tended to have larger waists than those in less deprived areas. This association was not observed for boys.

- Increasing crime in school neighbourhoods was associated with an increase in Waist SDS for Nigerian/Ghanaian girls and White UK boys and girls, but a decrease for Indian boys. It was also associated with an increase in BMI SDS for White UK girls.

- Increasing residential road density was associated with an increase in body size for Black Caribbean boys. A higher proportion of roads around a school was associated with a higher BMI SDS for girls.

- Girls who attended a school in a neighbourhood with a higher proportion of green space had smaller body size measures than girls in schools in less green areas. Residential neighbourhood green space was not associated with body size.

5.4 Choice of variables for inclusion in final models

In this chapter the association between each of the neighbourhood characteristics and body size was tested (after adjustment for age, pubertal status, and height). A selection of these variables was chosen for inclusion in the final models which adjust for school and individual/family factors (Chapter 7). Variables were selected for inclusion in these final models if they had shown an association with body size in the univariate analysis or if there were strong theoretical reasons to include them.

As neighbourhood crime is a component of the deprivation measure (IMD) it was not possible to include both of these measures in the final models. Deprivation was selected as it was related to Waist SDS for girls. The ethnic density variables were also selected as a key interest was the interaction between ethnic density and deprivation. Finally, the four subjective neighbourhood variables were selected; although they did not show a significant association with body size in the univariate analysis it was of interest whether interactions with deprivation and ethnic density might prove significant.

There was no statistical limit on the number of residential neighbourhood variables that could be included as these were included as individual-level covariates in the model. However the school neighbourhood variables were school-level variables; it was therefore not possible to include them in addition to the four school variables already selected in the previous Chapter. It was decided that as residential neighbourhood characteristics were already being included in the final model, the exclusion of school characteristics in favour of school neighbourhood characteristics could not be theoretically justified.

6 Individual and Family Characteristics and their association with body size

Previous cross-sectional analysis of the first wave of the DASH study identified individual and family characteristics which were correlates of overweight and obesity at 11-13yrs; these included skipping breakfast, maternal overweight, and maternal smoking (Harding et al., 2008b). This thesis extends this work by examining whether these correlates remained significant in longitudinal analyses, and by including additional variables available from wave 2 of the DASH survey which the literature base suggested could be related to body size. The variables considered in this chapter are wide-ranging and include measures of pupils' diets and activity levels, parental lifestyles, socio-economic status (SES), and acculturation. This chapter is split into two sections; in the first ethnic, age and sex differences in the characteristics are described. The patterning of the individual and parental measures by SES, and the associations between the acculturation measures and generational status, are then examined. The second part of this chapter then focuses on whether any of the factors were significantly associated with body size in adolescence, and if they explained any of the variance in body size at any level of the models. Whether the associations differed by ethnicity or age is also considered.

The aims of this chapter were to:

1. Determine if the ethnic and gender differences in the individual and family characteristics previously observed at 11-13yrs remained at 14-16yrs, and to examine ethnic and sex differences for the first time in the variables included only at 14-16yrs.

2. Determine whether the relationships found in previous work between overweight and obesity and individual and family characteristics at 11-13yrs were also apparent for BMI and waist, and whether they remained significant correlates in the longitudinal analyses.

3. Determine whether the individual or family characteristics explained any of the variance in body size at the measurement, individual or school level.

6.1 Ethnic, sex and age differences in the individual and family characteristics

6.1.1 Pupil behaviours

6.1.1.1 Physical Activity

Number of activities and number of activity sessions

The number of different activities and the number of activity sessions variables were available at both 11-13yrs and 14-16yrs (although as detailed in the Methods Chapter they were not measured in the same way at both ages). For both boys and girls, there were no significant ethnic differences in the mean number of different activities reported at either 11-13yrs or 14-16yrs (boys Table 6.1; girls Table 6.2). At both ages, the boys reported doing a greater number of activities than the girls. The boys and girls in every ethnic group (with the exception of the Indian and Pakistani/Bangladeshi girls) were significantly more likely to be in the lowest number of activities quartile (Q1) and significantly less likely to be in the highest number of activities quartile (Q4) at 14-16yrs than 11-13yrs. For example, 26% of the White UK boys were in Q1 at 11-13yrs compared to 48% at 14-16yrs. Similarly, 22% were in Q4 at 11-13yrs compared to only 5% at 14-16yrs.

There were also few significant ethnic differences in the number of activity sessions reported. Of the boys, the White UK were the most likely to be in the lowest number of sessions quartile (Q1) at both ages. The Nigerian/Ghanaian boys were significantly less likely to be in Q1 at 11-13yrs than the White UK boys. Of the girls, the Indians were the most likely to be in Q1 at both ages. At 11-16yrs the Indian girls were the least likely to have the highest number of sessions (Q4) and at 14-16yrs the White UK girls were least likely. At 14-16yrs, the Other African girls were significantly more likely to be in Q4 than the White UK girls. Boys reported more exercise sessions than girls in all ethnic groups and at both ages. The boys and girls in all ethnic groups were significantly more likely to be in the lowest number of sessions quartile and significantly less likely to be in the highest number of sessions quartile at 14-16yrs compared to 11-13yrs.

The proportion of boys who reported doing no activity was small at both ages (ranging from 2.1% of the Indians to 3.5% of the White UK at 11-13yrs, and from 3.9% of the Black Caribbeans to 7.2% of the Indians at 14-16yrs). Ethnic differences were not significant at either age. Proportions were slightly higher at 14-16yrs compared to 11-13yrs in every ethnic group, but these age differences were not statistically significant.

The girls were more likely than the boys to report doing no activity. At 11-13yrs, the Indian (16.0%) and Pakistani/Bangladeshi (11.4%) girls were significantly more likely to have done no activity than the White UK girls (4.5%). There were no significant ethnic differences at 14-16yrs. The proportions were higher at 14-16yrs than 11-13yrs in every ethnic group except the Indians; significantly so for the White UK and Black Caribbean girls (the two groups with the lowest proportions at 11-13yrs). The Indian girls were the only ethnic/sex group in which the proportion doing no activity decreased (from 16.0% at 11-13yrs to 10.5% at 14-16yrs). Therefore the Indian girls went from being most likely to report no activity at 11-13yrs to least likely at 14-16yrs. At 14-16yrs the Other Africans were the most likely to report no activity; this group were also the most likely to be in the highest number of activity sessions quartile (Q4) showing that girls in this group were at both ends of the activity spectrum, many being very active and many being inactive.

Further analysis was conducted to investigate whether the increase in number of pupils reporting no activity at 14-16yrs compared to 11-13yrs explained the drop in mean number of activity sessions observed at the older age. Those who were active reported less activity sessions at 14-16yrs than at 11-13yrs. Therefore it was not just that more people were doing no activity which explained the drop at 14-16yrs; activity levels of those who were active also decreased.

Breathless activity and time spent in activity

Breathlessness and activity time were measured only at 14-16yrs (boys Table 6.3; girls Table 6.4). There were no significant ethnic differences in the number of breathless activity sessions for either boys or girls. The boys reported a higher number of breathless activity sessions than the girls. The proportion of all activity sessions which were breathless was calculated. Of all the groups, the Indian girls reported the lowest percentage; 63.9% (95% CI: 57.9% to 69.8%) of their activity sessions were breathless compared to 75.8% (95% CI: 71.3% to 80.3%) of the Other African boys' sessions. In all ethnic groups, boys reported that a higher proportion of their exercise sessions were breathless compared to the girls. There were no significant ethnic differences within sex. Therefore the boys took part in a greater number of exercise sessions than the girls, and a greater proportion of them were breathless compared to the girls.

There were no significant ethnic differences for either total activity time or breathless activity time for either boys or girls. The boys spent an average of 403 (95% CI: 388 to 418) minutes (6.7 hours) being active in the previous 7 days, with 311 (95% CI: 285 to 338) minutes (5.2 hours) of that being breathless. Girls reported significantly less than this; 228 (216 to 241) minutes (3.8 hours) of activity time, of which 157 (146 to 167) minutes (2.6 hours) was breathless. The boys therefore reported spending more time in breathless activity than the girls reported spending in total activity.

Active Commute to School (14-16yrs)

Mode of transport to and from school was only measured at 14-16yrs. The proportion of pupils using active transport to and/or from school was assessed (i.e. the proportion walking or cycling at least one way). The White UK, Indian and Pakistani/Bangladeshi boys and girls were significantly more likely to use active transportation than their Black Caribbean, Nigerian/Ghanaian, and Other African peers. The Pakistani/Bangladeshi boys (67.2%) and girls (62.9%) were the most likely to actively commute at least one way, and the Nigerian/Ghanaian boys (30.0%) and girls (24.9%) least likely. Of those using active transport, the vast majority walked; only 37 boys reported that they cycled both to and from school, and no girls did. There were few ethnic differences and no significant sex differences in the length of commute of those who walked to school (this variable was not imputed). The average length of commute for boys was 16.0 (15.4-16.7) minutes and for girls 16.8 (15.9-17.6) minutes. The only significant ethnic difference was for Pakistani/Bangladeshi girls who walked a mean of 14.1 minutes and this was significantly shorter than the White UK girls' mean of 17.7 minutes.

The modes of transport used by the pupils were examined to determine how the pupils who were not actively commuting were getting to and from school (these data were not imputed). For all groups active transportation and public transport accounted for the vast majority of journeys. The Indians, Pakistanis/Bangladeshis and White UK pupils were the most likely to have travelled by car; over 12% of Pakistani/Bangladeshi girls travelled by car both to and from school compared to none of the Other African boys.

Sedentary behaviour

The sedentary score was calculated by summing the responses to the six sedentary behaviours: talking on phone, using internet, playing computer games, texting, reading/listening to music, and watching TV. The Black Caribbean and Indian boys were significantly less likely to be in the lowest sedentary score quintile (Q1), and the Black Caribbean, Nigerian/Ghanaian and Indian boys significantly more likely to be in the highest sedentary quintile (Q4), than the White UK boys (Table 6.3). The Nigerian/Ghanaian girls were significantly less likely to be in Q1 and significantly more likely to be in Q4 compared to the White UK girls (Table 6.4). Unlike the physical activity measures, there was no significant difference between the boys (6.3, 95% CI 6.1 to 6.4) and girls (6.2, 6.0 to 6.4) in their mean sedentary score.

Although there were no gender differences overall, the detailed examination of each of the sedentary behaviours did reveal sex differences. The boys were much more likely to report playing computer games, and the girls read/listened to music and talked on the phone more than the boys. Watching television and reading/listening to music were popular activities with nearly all of the pupils. Overall, the pupils spent a considerable amount of time in sedentary activities irrespective of gender or ethnicity.

Table 6.1 Boys: Activity Measures at 11-13yrs and 14-16yrs by ethnicity

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N		490	389	207	209	237	305
No physical activity in 7 days							
No activity (%)	11-13	3.5 (1.8-5.1)	3.1 (1.4-4.8)	2.4 (0.3-4.5)	2.4 (0.3-4.5)	2.1 (0.3-4.0)	2.6 (0.8-4.4)
	14-16	4.8 (3.9-5.8)	3.9 (2.2-5.6)	5.4 (3.1-7.7)	5.3 (2.2-8.4)	7.2 (3.6-10.7)	4.6 (1.9-7.3)
Number of different activities in 7 days							
Mean number	11-13	3.89 (3.71-4.07)	3.97 (3.76-4.17)	4.06 (3.80-4.32)	3.83 (3.56-4.11)	4.26 (4.01-4.51)	3.96 (3.75-4.18)
	14-16	2.77 (2.63-2.92)	2.84 (2.67-3.01)	3.13 (2.86-3.39)	2.70 (2.49-2.91)	3.02 (2.81-3.24)	2.91 (2.71-3.11)
Q1 (0-2 activities) (%)	11-13	25.9 (22.0-29.8)	26.0 (21.6-30.3)	20.8 (15.2-26.3)	29.7 (23.4-35.9)	19.4 (14.3-24.5)	24.6 (19.7-29.5)
	14-16	47.6 (43.1-52.0)^	46.3 (41.3-51.2)^	41.5 (34.8-48.3)^	46.4 (39.6-53.2)^	40.9 (34.6-47.2)^	47.2 (41.6-52.8)^
Q2 (3 activities) (%)	11-13	18.2 (14.7-21.6)	18.5 (14.6-22.4)	20.3 (14.8-25.8)	16.7 (11.6-21.9)	17.3 (12.4-22.2)	15.1 (11.0-19.1)
	14-16	24.3 (20.5-28.1)	21.1 (17.0-25.2)	22.2 (16.5-27.9)	23.9 (18.1-29.8)	22.4 (17.0-27.7)	22.0 (17.3-26.6)
Q3 (4-5 activities) (%)	11-13	33.9 (29.7-38.1)	32.4 (27.7-37.1)	37.2 (30.6-43.8)	35.9 (29.3-42.4)	34.6 (28.5-40.7)	40.0 (34.5-45.5)
	14-16	22.9 (19.1-26.6)^	28.0 (23.5-32.5)	27.1 (21.0-33.2)	25.8 (19.9-31.8)	29.1 (23.3-34.9)	22.0 (17.3-26.6)^
Q4 (6+ activities) (%)	11-13	22.0 (18.4-25.7)	23.1 (18.9-27.3)	21.7 (16.1-27.4)	17.7 (12.5-22.9)	28.7 (22.9-34.5)	20.3 (15.8-24.9)
	14-16	5.3 (3.3-7.3)^	4.6 (2.5-6.7)^	9.2 (5.2-13.1)^	3.8 (1.2-6.5)^	7.6 (4.2-11.0)^	8.9 (5.6-12.1)^
Number of activity sessions in 7 days							
Mean number	11-13	12.2 (11.6-12.9)	12.7 (12.1-13.4)	14.1 (13.2-15.0)	13.3 (12.4-14.1)	12.8 (12.0-13.7)	13.3 (12.5-14.1)
	14-16	6.8 (6.4-7.3)^	7.4 (6.9-7.9)^	8.1 (7.3-8.9)^	7.3 (6.6-7.9)^	7.2 (6.5-7.9)	7.3 (6.6-7.9)
Q1 (0-5 sessions) (%)	11-13	17.6 (14.2-20.9)	15.2 (11.6-18.7)	9.2 (5.2-13.1)*	12.4 (7.9-17.0)	16.5 (11.7-21.2)	13.1 (9.3-16.9)
	14-16	47.8 (43.3-52.2)^	39.6 (34.7-44.5)^	40.6 (33.8-47.3)^	41.1 (34.4-47.9)^	46.0 (39.6-52.4)^	44.3 (38.7-49.9)^
Q2 (6-9 sessions) (%)	11-13	22.2 (18.5-25.9)	20.3 (16.3-24.3)	18.8 (13.5-24.2)	18.2(12.9-23.5)	21.5 (16.2-26.8)	19.3 (14.9-23.8)
	14-16	28.0 (24.0-31.9)	31.4 (26.7-36.0)	23.7 (17.8-29.5)	29.2 (23.0-35.4)	26.6 (20.9-32.2)	26.9 (21.9-31.9)
Q3 (10-15 sessions) (%)	11-13	27.6 (23.6-31.5)	30.1 (25.5-34.7)	32.4 (25.9-38.8)	31.6 (25.2-37.9)	24.1 (18.6-29.5)	27.9 (22.8-32.9)
	14-16	17.6 (14.2-20.9)	21.3 (17.2-25.4)	24.2 (18.3-30.0)	22.0 (16.3-27.7)	19.4 (14.3-24.5)	20.7 (16.1-25.2)
Q4 (16+ sessions) (%)	11-13	32.7 (28.5-36.8)	34.4 (29.7-39.2)	39.6 (32.9-46.3)	37.8 (31.2-44.4)	38.0 (31.8-44.2)	39.7 (34.2-45.2)
	14-16	6.7 (4.5-9.0)^	7.7 (5.0-10.4)^	11.6 (7.2-16.0)^	7.7 (4.0-11.3)^	8.0 (4.5-11.5)^	8.2 (5.1-11.3)

*Significantly different from White UK, ^ Value at 14-16yrs significantly different to 11-13yrs within ethnic group (significance determined by non-overlapping confidence intervals)

Table 6.2 Girls: Activity Measures at 11-13yrs and 14-16yrs by ethnicity

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N		380	389	297	177	181	140
No physical activity in 7 days							
No activity (%)	11-13	4.5 (2.4-6.6)	5.4 (3.1-7.7)	9.4 (6.1-12.8)	9.0 (4.8-13.3)	16.0 (10.6-21.4)*	11.4 (6.1-16.8)*
	14-16	11.6 (8.3-14.8)^	14.9 (11.4-18.5)^	12.8 (9.0-16.6)	17.5 (11.9-23.2)	10.5 (6.0-15.0)	17.1 (10.8-23.5)
Number of different activities in 7 days							
Mean number	11-13	3.4 (3.2-3.6)	3.3 (3.1-3.5)	3.2 (3.0-3.4)	3.1 (2.8-3.5)	2.6 (2.3-2.9)	3.2 (2.9-3.6)
	14-16	2.2 (2.1-2.4)^	2.2 (2.0-2.4)^	2.2 (2.0-2.4)^	2.4 (2.1-2.7)^	2.5 (2.2-2.7)	2.5 (2.2-2.9)
Q1 (0-2 activities) (%)	11-13	17.4 (13.5-21.2)	22.4 (18.2-26.5)	22.2 (17.5-27.0)	24.3 (17.9-30.7)	34.8 (27.8-41.8)	23.6 (16.5-30.7)
	14-16	37.9 (33.0-42.8)^	41.1 (36.2-46.0)^	38.4 (32.8-43.9)^	37.3 (30.1-44.5)	32.0 (25.2-38.9)	35.0 (27.0-43.0)
Q2 (3 activities) (%)	11-13	20.8 (16.7-24.9)	19.5 (15.6-23.5)	17.5 (13.2-21.9)	19.2 (13.3-25.1)	18.8 (13.0-24.5)	18.6 (12.0-25.1)
	14-16	23.9 (19.6-28.3)	21.3 (17.2-25.4)	24.9 (20.0-29.9)	18.6 (12.9-24.4)	25.4 (19.0-31.8)	22.9 (15.8-29.9)
Q3 (4-5 activities) (%)	11-13	33.9 (29.2-38.7)	29.8 (25.3-34.4)	34.3 (28.9-39.8)	31.1 (24.2-38.0)	26.5 (20.0-33.0)	31.4 (23.6-39.2)
	14-16	30.5 (25.9-35.2)	26.7 (22.3-31.2)	27.6 (22.5-32.7)	31.6 (24.7-38.6)	30.4 (23.6-37.2)	25.7 (18.4-33.0)
Q4 (6+ activities) (%)	11-13	27.9 (23.4-32.4)	28.3 (23.8-32.8)	25.9 (20.9-30.9)	25.4 (18.9-31.9)	19.9 (14.0-25.8)	26.4 (19.0-33.8)
	14-16	7.6 (5.0-10.3)^	10.8 (7.7-13.9)^	9.1 (5.8-12.4)^	12.4 (7.5-17.3)^	12.2 (7.3-17.0)	16.4 (10.2-22.6)
Number of activity sessions in 7 days							
Mean number	11-13	9.5 (8.7-10.2)	10.6 (9.8-11.3)	10.7 (9.9-11.5)	9.9 (8.9-11.0)	7.4 (6.4-8.3)*	9.9 (8.6-11.1)
	14-16	4.1 (3.7-4.5)^	5.0 (4.5-5.4)^*	5.3 (4.8-5.9)^*	5.1 (4.3-5.8)^	4.4 (3.8-5.0)^	4.9 (4.2-5.7)^
Q1 (0-5 sessions) (%)	11-13	19.5 (15.5-23.5)	15.9 (12.3-19.6)	15.8 (11.7-20.0)	18.1 (12.4-23.8)	29.8 (23.1-36.6)	19.3 (12.7-25.9)
	14-16	40.3 (35.3-45.2)^	41.1 (36.2-46.0)^	36.7 (31.2-42.2)^	41.2 (33.9-48.6)^	41.4 (34.2-48.7)	39.3 (31.1-47.5)^
Q2 (6-9 sessions) (%)	11-13	18.4 (14.5-22.3)	13.1 (9.7-16.5)	10.8 (7.2-14.3)	10.7 (6.1-15.3)	22.1 (16.0-28.2)	17.9 (11.4-24.3)
	14-16	33.2 (28.4-37.9)^	23.4 (19.2-27.6)^*	24.2 (19.3-29.1)^	19.8 (13.8-25.7)*	28.7 (22.1-35.4)	21.4 (14.5-28.3)
Q3 (10-15 sessions) (%)	11-13	27.6 (23.1-32.1)	31.6 (27.0-36.3)	29.3 (24.1-34.5)	33.9 (26.9-40.9)	24.3 (18.0-30.6)	25.7 (18.4-33.0)
	14-16	21.3 (17.2-25.5)	25.7 (21.3-30.1)	28.6 (23.4-33.8)	26.6 (20.0-33.1)	21.5 (15.5-27.6)	30.0 (22.3-37.7)
Q4 (16+ sessions) (%)	11-13	34.5 (29.7-39.3)	39.3 (34.5-44.2)	44.1 (38.4-49.8)	37.3 (30.1-44.5)	23.8 (17.5-30.0)	37.1 (29.0-45.2)
	14-16	5.3 (3.0-7.5)^	9.8 (6.8-12.7)^	10.4 (6.9-13.9)^	12.4 (7.5-17.3)^*	8.3 (4.2-12.3)^	9.3 (4.4-14.2)^

*Significantly different from White UK, ^ Value at 14-16yrs significantly different to 11-13yrs within ethnic group (significance determined by non-overlapping confidence intervals)

Table 6.3 Boys: Activity Measures at 14-16yrs only by ethnicity

	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N	490	389	207	209	237	305
Number of Breathless sessions in 7 days						
Mean number	5.09 (4.7-5.5)	5.1 (4.7-5.6)	5.7 (5.0-6.5)	5.6 (4.9-6.2)	5.0 (4.4-5.5)	5.7 (5.1-6.3)
Q1 (0-2 sessions) (%)	32.4 (28.3-36.6)	33.7 (29.0-38.4)	33.3 (26.9-39.8)	31.6 (25.2-37.9)	35.4 (29.3-41.6)	33.8 (28.4-39.1)
Q2 (3-4 sessions) (%)	21.0 (17.4-24.6)	17.2 (13.5-21.0)	17.9 (12.6-23.1)	18.2 (12.9-23.5)	21.5 (16.2-26.8)	15.7 (11.6-19.8)
Q3 (5-8 sessions) (%)	28.0 (24.0-31.9)	29.6 (25.0-34.1)	22.2 (16.5-27.9)	25.4 (19.4-31.3)	24.1 (18.6-29.5)	26.6 (21.6-31.5)
Q4 (9+ sessions) (%)	18.6 (15.1-22.0)	19.5 (15.6-23.5)	26.6 (20.5-32.6)	24.9 (19.0-30.8)	19.0 (14.0-24.0)	23.9 (19.1-28.8)
Total Activity Time						
Time (mins)	402 (374-431)	410 (376-443)	445 (397-493)	390 (348-433)	377 (338-415)	396 (361-431)
Q1 (0 -150 mins) (%)	25.7 (21.8-29.6)	24.9 (20.6-29.3)	23.7 (17.8-29.5)	28.7 (22.5-34.9)	26.6 (20.9-32.2)	25.2 (20.3-30.1)
Q2 (155 - 330 mins) (%)	25.7 (21.8-29.6)	25.7 (21.3-30.1)	20.8 (15.2-26.3)	22.5 (16.8-28.2)	29.1 (23.3-34.9)	24.9 (20.0-29.8)
Q3 (335 - 570 mins) (%)	24.5 (20.7-28.3)	23.1 (18.9-27.3)	24.6 (18.7-30.6)	24.4 (18.5-30.3)	21.5 (16.2-26.8)	26.9 (21.9-31.9)
Q4 (580 - 1785 mins) (%)	24.1 (20.3-27.9)	26.2 (21.8-30.6)	30.9 (24.6-37.3)	24.4 (18.5-30.3)	22.8 (17.4-28.2)	23.0 (18.2-27.7)
Total breathless time						
Breathless time (mins)	311 (285-338)	298 (268-329)	325 (280-369)	312 (271-352)	269 (236-302)	312 (278-345)
Q1 (0-70 mins)	24.3 (20.5-28.1)	28.8 (24.3-33.3)	27.1 (21.0-33.2)	23.4 (17.7-29.2)	26.2 (20.5-31.8)	21.3 (16.7-25.9)
Q2 (>70-240 mins)	26.9 (23.0-30.9)	26.7 (22.3-31.2)	22.2 (16.5-27.9)	30.6 (24.3-36.9)	32.1 (26.1-38.1)	30.5 (25.3-35.7)
Q3 (>240-450 mins)	24.1 (20.3-27.9)	18.8 (14.9-22.7)	25.1 (19.2-31.1)	19.6 (14.2-25.0)	22.4 (17.0-27.7)	25.9 (21.0-30.8)
Q4 (453-1739 mins)	24.7 (20.9-28.5)	25.7 (21.3-30.1)	25.6 (19.6-31.6)	26.3 (20.3-32.3)	19.4 (14.3-24.5)	22.3 (17.6-27.0)
Active commute to/from school						
One or both ways (%)	63.3 (59.0-67.5)	41.6 (36.7-46.6)*	30.0 (23.7-36.2)*	35.9 (29.3-42.4)*	65.0 (58.9-71.1)	67.2 (61.9-72.5)
Sedentary behaviour						
Mean score	5.75 (5.48-6.01)	6.66 (6.32-7.01)*	6.80 (6.29-7.31)*	6.27 (5.83-6.70)	6.89 (6.45-7.33)*	5.89 (5.54-6.24)
Q1 (0-4) (%)	35.3 (31.1-40.0)	25.7 (21.3-30.1)*	25.1 (19.2-31.1)	28.7 (22.5-34.9)	24.9 (19.3-30.4)*	32.8 (27.5-38.1)
Q2 (4.5-6) (%)	26.9 (23.0-30.9)	24.4 (20.1-28.7)	29.0 (22.8-35.2)	30.1 (23.9-36.4)	23.6 (18.2-29.1)	26.9 (21.9-31.9)
Q3 (6.5-8) (%)	19.8 (16.3-23.3)	22.9 (18.7-27.1)	15.5 (10.5-20.4)	15.3 (10.4-20.2)	20.3 (15.1-25.4)	20.7 (16.1-25.2)
Q4 (8.5-21) (%)	18.0 (14.5-21.4)	27.0 (22.6-31.4)*	30.4 (24.1-36.8)*	25.8 (19.9-31.8)	31.2 (25.3-37.2)*	19.7 (15.2-24.2)

*Significantly different from White UK, ^ Value at 14-16yrs significantly different to 11-13yrs within ethnic group (significance determined by non-overlapping confidence intervals)

Table 6.4 Girls: Activity Measures at 14-16yrs only by ethnicity

	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N	380	389	297	177	181	140
Number of Breathless sessions in 7 days						
Mean number	2.8 (2.5-3.1)	3.3 (2.9-3.7)	3.6 (3.1-4.0)	3.7 (3.1-4.3)	2.9 (2.4-3.4)	3.2 (2.6-3.8)
Q1 (0-2 sessions) (%)	26.1 (21.6-30.4)	30.8 (26.2-35.5)	27.6 (22.5-32.7)	26.6 (20.0-33.1)	27.1 (20.5-33.6)	27.9 (20.3-35.4)
Q2 (3-4 sessions) (%)	31.3 (26.6-36.0)	26.2 (21.8-30.6)	25.6 (20.6-30.6)	26.0 (19.5-32.5)	30.4 (23.6-37.2)	27.1 (19.7-34.6)
Q3 (5-8 sessions) (%)	26.3 (21.9-30.8)	20.8 (16.8-24.9)	23.2 (18.4-28.1)	20.9 (14.9-27.0)	26.5 (20.0-33.0)	22.1 (15.2-29.1)
Q4 (9+ sessions) (%)	16.3 (12.6-20.0)	22.1 (18.0-26.2)	23.6 (18.7-28.4)	26.6 (20.0-33.1)	16.0 (10.6-21.4)	22.9 (15.8-29.9)
Total Activity Time						
Time (mins)	214 (191-237)	252 (225-279)	221 (192-251)	253 (211-294)	208 (173-242)	213 (173-253)
Q1 (0 -150 mins) (%)	29.7 (25.1-34.4)	30.6 (26.0-35.2)	32.7 (27.3-38.0)	29.4 (22.6-36.2)	29.8 (23.1-36.6)	30.7 (23.0-38.5)
Q2 (155 - 330 mins) (%)	22.1 (17.9-26.3)	20.3 (16.3-24.3)	22.9 (18.1-27.7)	19.2 (13.3-25.1)	26.5 (20.0-33.0)	20.7 (13.9-27.5)
Q3 (335 - 570 mins) (%)	26.1 (21.6-30.5)	20.6 (16.5-24.6)	22.6 (17.8-27.3)	23.7 (17.4-30.1)	26.5 (20.0-33.0)	25.7 (18.4-33.0)
Q4 (580 - 1785 mins) (%)	22.1 (17.9-26.3)	28.5 (24.0-33.0)	21.9 (17.2-26.6)	27.7 (21.0-34.3)	17.1 (11.6-22.7)	22.9 (15.8-29.9)
Total breathless time						
Breathless time (mins)	145 (127-164)	171 (147-195)	153 (128-178)	186 (151-221)	136 (109-164)	145 (115-174)
Q1 (0-70 mins)	26.1 (21.6-30.5)	30.8 (26.2-35.5)	27.6 (22.5-32.7)	26.6 (20.0-33.1)	27.1 (20.5-33.6)	27.9 (20.3-35.4)
Q2 (>70-240 mins)	23.9 (19.6-28.3)	19.5 (15.6-23.5)	24.6 (19.7-29.5)	16.4 (10.9-21.9)	24.9 (18.5-31.2)	23.6 (16.5-30.7)
Q3 (>240-450 mins)	26.6 (22.1-31.0)	22.6 (18.4-26.8)	24.9 (20.0-29.9)	26.0 (19.5-32.5)	29.8 (23.1-36.6)	24.3 (17.1-31.5)
Q4 (453-1739 mins)	23.4 (19.1-27.7)	27.0 (22.6-31.4)	22.9 (18.1-27.7)	31.1 (24.2-38.0)	18.2 (12.6-23.9)	24.3 (17.1-31.5)
Active commute to/from school						
One or both ways (%)	56.3 (51.3-61.3)	34.2 (29.5-38.9)*	24.9 (20.0-29.9)*	26.6 (20.0-33.1)*	59.1 (51.9-66.3)	62.9 (54.8-71.0)
Sedentary behaviour						
Mean score	5.7 (5.4-6.0)	6.5 (6.2-6.9)*	6.8 (6.4-7.2)*	6.5 (5.9-7.0)	5.8 (5.4-6.3)	5.6 (5.1-6.2)
Q1 (0-4) (%)	38.7 (33.8-43.6)	29.8 (25.3-34.4)	26.3 (21.2-31.3)*	27.7 (21.0-34.3)	32.0 (25.2-38.9)	37.9 (29.7-46.0)
Q2 (4.5-6) (%)	21.3 (17.2-25.5)	15.2 (11.6-18.7)	16.5 (12.3-20.7)	19.8 (13.8-25.7)	25.4 (19.0-31.8)	22.9 (15.8-29.9)
Q3 (6.5-8) (%)	21.8 (17.7-26.0)	30.3 (25.7-34.9)	29.0 (23.8-34.1)	26.0 (19.5-32.5)	24.9 (18.5-31.2)	22.1 (15.2-29.1)
Q4 (8.5-21) (%)	18.2 (14.3-22.1)	24.7 (20.4-29.0)	28.3 (23.1-33.4)*	26.6 (20.0-33.1)	17.7 (12.1-23.3)	17.1 (10.8-23.5)

*Significantly different from White UK, ^ Value at 14-16yrs significantly different to 11-13yrs within ethnic group (significance determined by non-overlapping confidence intervals)

6.1.1.2 Diet

Two measures of the pupils' diets were considered; how frequently they ate breakfast and their consumption of fruit and vegetables. Ethnic differences in these measures in the Wave 1 sample (at 11-13yrs) have previously been reported (Harding et al., 2008b). The summary statistics presented here show similar overall patterns to those in the paper but figures do not match exactly due to the sample in this thesis being restricted to those who participated in Wave 2 only and due to missing data being imputed in this thesis but not in the paper. Furthermore, in the paper the Black African group was not disaggregated into Nigerian/Ghanaian and Other African.

Data on breakfast consumption was available at 11-13yrs only (Table 6.5). Over half of the girls reported skipping breakfast (51.5%), a significantly higher proportion than the boys (36.4%). For both boys and girls, the Nigerian/Ghanaians were the most likely to report skipping breakfast and the Indians least likely. For the boys, the Nigerian/Ghanaian, Other African, and Black Caribbean boys were significantly more likely to report skipping breakfast than the White UK, Pakistani/Bangladeshi, and Indian boys. For the girls, the Nigerian/Ghanaian, Black Caribbean, Other African and Pakistani/Bangladeshi girls had significantly higher proportions skipping breakfast than the White UK and Indian girls. Therefore the Pakistani/Bangladeshi boys were one of the groups least likely to skip breakfast, but the Pakistani/Bangladeshi girls one of the most likely.

Fruit and vegetable consumption was measured at both 11-13yrs and 14-16yrs. Many of the pupils reported low fruit and vegetable consumption; only a third of the pupils ate ≥5 portions of fruit and vegetables per day, and more than a quarter ate <1 portion per day. For both boys and girls, the White UK and Indians were the most likely to eat ≥5 portions and least likely to eat <1 portion at both ages. For boys, the Nigerian/Ghanaian and Pakistani/Bangladeshi boys were significantly less likely to report eating ≥5 portions than the White UK boys at both 11-13yrs and 14-16yrs. Compared to the White UK and Indian boys, the Other African boys were significantly more likely to have low consumption (<1 portion) at 11-13yrs, and the Nigerian/Ghanaians, Other Africans, Black Caribbeans, and Pakistani/Bangladeshis at 14-16yrs.

For the girls, compared to the White UK and Indians, the Nigerian/Ghanaians were significantly less likely at both ages, and the Black Caribbeans, Other Africans and Pakistani/Bangladeshis at 14-16yrs, to eat ≥5 portions. The Other Africans were significantly more likely than the White UK and Indian girls to eat <1 portion at both ages; this was also true of the Black Caribbean, Nigerian/Ghanaian and Pakistani/Bangladeshi girls at 14-16yrs.

Overall, there were no gender differences in fruit and vegetable consumption and there was little difference by age; for example the proportion that ate ≥5 portions per day was similar at both ages and for both sexes. Within ethnic group the only significant age difference was for the Nigerian/Ghanaian boys; a significantly higher proportion reported eating <1 portion at 14-16yrs (39.6%) than 11-13yrs (26.6%).

Table 6.5 Diet measures by gender, age and ethnicity

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys	n	490	389	207	209	237	305
Breakfast							
Does not eat breakfast everyday	11-13	30.6 (26.5-34.7)	42.2 (37.2-47.1)*	55.6 (48.7-62.4)*	51.2 (44.4-58.0)*	22.8 (17.4-28.2)	25.6 (20.6-30.5)
Fruit and Vegetables							
≥5 portions per day	11-13	39.2 (34.8-43.5)	32.9 (28.2-37.6)	26.1 (20.1-32.1)*	30.6 (24.3-36.9)	39.2 (33.0-45.5)	26.6 (21.6-31.5)*
	14-16	36.1 (31.9-40.4)	28.8 (24.3-33.3)	21.7 (16.1-27.4)*	29.7 (23.4-35.9)	35.4 (29.3-41.6)	24.9 (20.0-29.8)*
1-4 portions per day	11-13	41.2 (36.9-45.6)	42.7 (37.7-47.6)	47.3 (40.5-54.2)	35.9 (29.3-42.4)	44.3 (37.9-50.7)	45.9 (40.3-51.5)
	14-16	44.9 (40.5-49.3)	39.1 (34.2-43.9)	38.6 (32.0-45.3)	36.4 (29.8-42.9)	48.1 (41.7-54.5)	44.9 (39.3-50.5)
<1 portion per day	11-13	19.6 (16.1-23.1)	24.4 (20.1-28.7)	26.6 (20.5-32.6)	33.5 (27.0-39.9)*	16.5 (11.7-21.2)	27.5 (22.5-32.6)
	14-16	19.0 (15.5-22.5)	32.1 (27.5-36.8)*	39.6 (32.9-46.3)^*	34.0 (27.5-40.4)*	16.5 (11.7-21.2)	30.2 (25.0-35.3)*
Girls	n	380	389	297	177	181	140
Breakfast							
Does not eat breakfast everyday	11-13	40.3 (35.3-45.2)	59.4 (54.5-64.3)*	62.0 (56.4-67.5)*	56.5 (49.1-63.9)*	32.6 (25.7-39.5)	55.7 (47.4-64.0)*
Fruit and Vegetables							
≥5 portions per day	11-13	36.3 (31.5-41.2)	30.8 (26.2-35.5)	25.9 (20.9-30.9)*	31.6 (24.7-38.6)	39.8 (32.6-47.0)	31.4 (23.6-39.2)
	14-16	41.1 (36.1-46.0)	26.5 (22.1-30.9)*	21.5 (16.8-26.3)*	23.7 (17.4-30.1)*	39.8 (32.6-47.0)	25.7 (18.4-33.0)*
1-4 portions per day	11-13	41.6 (36.6-46.6)	40.1 (35.2-45.0)	38.7 (33.1-44.3)	35.0 (27.9-42.1)	43.1 (35.8-50.4)	42.1 (33.9-50.4)
	14-16	38.9 (34.0-43.9)	36.8 (31.9-41.6)	41.4 (35.8-47.0)	36.2 (29.0-43.3)	44.8 (37.4-52.1)	40.0 (31.8-48.2)
<1 portion per day	11-13	22.1 (17.9-26.3)	29.0 (24.5-33.6)	35.4 (29.9-40.8)*	33.3 (26.3-40.3)*	17.1 (11.6-22.7)	26.4 (19.0-33.8)
	14-16	20.0 (16.0-24.0)	36.8 (31.9-41.6)*	37.0 (31.5-42.6)*	40.1 (32.8-47.4)*	15.5 (10.2-20.8)	34.3 (26.3-42.2)*

*Significantly different from White UK

^Value at 14-16yrs significantly different to 11-13yrs within ethnic group

(significance determined by non-overlapping confidence intervals)

6.1.1.3 Smoking

The majority of pupils in every ethnic group had never tried smoking at 11-13yrs; however there were significant ethnic differences (Table 6.6). For both boys and girls, the Indian pupils were the most likely to have never tried smoking and the Black Caribbean and White UK pupils the least likely. By 14-16yrs significantly more pupils reported having tried smoking in every sex and ethnic group except the Other African boys. However of those who had tried smoking, many had only tried once. The White UK girls were the most likely to be classified as smokers; over 30% at 14-16yrs, markedly higher than the proportions in the other ethnic groups (which ranged from 1.4% of Pakistani/Bangladeshi girls to 12.9% of Black Caribbean girls). Of the boys, the White UK were also the most likely to be smokers at 14-16yrs (16.1%), significantly higher than all of the other boys except the Pakistani/Bangladeshis (11.5%). Therefore sex differences in the ethnic patterning of smoking were evident; the White UK girls were almost twice as likely to be smokers as the White UK boys. Furthermore, the Pakistani/Bangladeshi girls had the lowest smoking rates of the girls, but the Pakistani/Bangladeshi boys the second highest of the boys. Few pupils reported that they had given up smoking.

Table 6.6 Smoking behaviour by gender, age and ethnicity

		White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys	n	490	389	207	209	237	305
Never tried (%)	11-13	73.5 (69.5-77.4)	73.3 (68.8-77.7)	86.0 (81.2-90.8)*	77.5 (71.8-83.2)	93.7 (90.5-96.8)*	77.4 (72.7-82.1)
	14-16	49.4 (44.9-53.8)^	63.8 (59.0-68.6)^*	74.9 (68.9-80.8)^*	72.7 (66.6-78.8)	75.9 (70.4-81.4)^*	62.0 (56.5-67.4)^*
Tried once (%)	11-13	21.6 (18.0-25.3)	23.7 (19.4-27.9)	13.5 (8.8-18.2)	21.1 (15.5-26.6)	5.5 (2.6-8.4)*	18.4 (14.0-22.7)
	14-16	30.0 (25.9-34.1)^	23.7 (19.4-27.9)	21.7 (16.1-27.4)	17.7 (12.5-22.9)*	15.2 (10.6-19.8)^*	20.0 (15.5-24.5)*
Given up (%)	11-13	3.3 (1.7-4.8)	1.8 (0.5-3.1)	0.5 (0.0-1.4)*	1.0 (0.0-2.3)	0.8 (0.0-2.0)	2.30 (0.6-4.0)
	14-16	4.5 (2.6-6.3)	5.4 (3.1-7.7)^	1.4 (0.0-3.1)	5.7 (2.6-8.9)^	3.0 (0.8-5.1)	6.6 (3.8-9.4)
Smoker (%)	11-13	1.6 (0.5-2.8)	1.3 (0.2-2.4)	0	0.5 (0.0-1.4)	0	2.0 (0.4-3.5)
	14-16	16.1 (12.9-19.4)^	7.2 (4.6-9.8)^*	1.9 (0.0-3.8)*	3.8 (1.2-6.5)*	5.9 (2.9-8.9)*	11.5 (7.9-15.1)^
Girls	n	380	389	297	177	181	140
Never tried (%)	11-13	73.2 (68.7-77.6)	70.7 (66.2-75.2)	86.5 (82.6-90.4)*	84.7 (79.4-90.1)*	94.5 (91.1-97.8)*	89.3 (84.1-94.5)*
	14-16	34.5 (29.7-39.3)^	45.2 (40.3-50.2)^*	70.0 (64.8-75.3)^*	66.1 (59.1-73.1)^*	72.4 (65.8-79.0)^*	66.4 (58.5-73.3)^*
Tried once (%)	11-13	17.4 (13.5-21.2)	23.1 (18.9-27.3)	12.5 (8.7-16.2)	14.1 (8.9-19.3)	5.0 (1.8-8.2)*	9.3 (4.4-14.2)
	14-16	27.1 (22.6-31.6)^	32.9 (28.2-37.6)^	22.2 (17.5-27.0)^	22.6 (16.4-28.8)	21.5 (15.5-27.6)^	26.4 (19.0-33.8)^
Given up (%)	11-13	4.7 (2.6-6.9)	2.6 (1.0-4.2)	0.3 (0.0-1.0)	0.6 (0.0-1.7)*	0.6 (0.0-1.6)*	0.7 (0.0-2.1)*
	14-16	7.9 (5.2-10.6)	9.0 (6.1-11.9)^	4.0 (1.8-6.3)^	3.4 (0.7-6.1)	2.2 (0.0-4.4)*	5.7 (1.8-9.6)
Smoker (%)	11-13	4.7 (2.6-6.9)	3.6 (1.7-5.5)	0.7 (0.0-1.6)*	0.6 (0.0-1.7)*	0	0.7 (0.0-2.1)*
	14-16	30.5 (25.9-35.2)^	12.9 (9.5-16.2)^*	3.7 (1.5-5.9)*	7.9 (3.9-11.9)^*	3.9 (1.0-6.7)*	1.4 (0.0-3.4)*

*Significantly different from White UK

^Value at 14-16yrs significantly different to 11-13yrs within ethnic group

(significance determined by non-overlapping confidence intervals)

6.1.1.4 Sleep

Sleep data was available at 14-16yrs only. On average, the pupils slept for around 8 hours on an average night (ranging from 7.89 hrs for Nigerian/Ghanaian girls to 8.39 hrs for White UK boys) (Table 6.7). The only significant ethnic difference in mean hours was for the Nigerian/Ghanaian girls; they reported a significantly shorter length of sleep than the White UK and Black Caribbean girls. Categories of the continuous variable were derived; again there were few ethnic differences. The Other African girls were significantly more likely to report 7 hrs sleep, and significantly less likely to report 8 hrs sleep, than their White UK peers. The Other African boys were significantly more likely to report ≤6hrs than White UK boys.

Table 6.7 Hours of sleep by gender and ethnicity (14-16yrs only)

	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
Boys	490	389	207	209	237	305
Mean (hours)	8.39 (8.27-8.51)	8.19 (8.04-8.34)	8.10 (7.91-8.28)	8.23 (8.01-8.46)	8.37 (8.19-8.55)	8.35 (8.20-8.51)
≤6 hrs	7.1 (4.9-9.4)	12.6 (9.3-15.9)	13.5 (8.8-18.2)	15.8 (10.8-20.8)*	7.6 (4.2-11.0)	8.5 (5.4-11.7)
7 hrs	14.9 (11.7-18.1)	17.5 (13.7-21.3)	16.4 (11.3-21.5)	14.4 (9.6-19.1)	18.1 (13.2-23.1)	14.1 (10.2-18.0)
8hrs	33.3 (29.1-37.5)	30.8 (26.2-35.5)	32.4 (25.9-38.8)	28.2 (22.1-34.4)	28.3 (22.5-34.0)	33.1 (27.8-38.4)
9hrs	26.7 (22.8-30.7)	21.1 (17.0-25.2)	21.7 (16.1-27.4)	22.0 (16.3-27.7)	27.0 (21.3-32.7)	26.9 (21.9-31.9)
≥10hrs	18.0 (14.5-21.4)	18.0 (14.2-21.8)	15.9 (10.9-21.0)	19.6 (14.2-25.0)	19.0 (14.0-24.0)	17.4 (13.1-21.7)
Girls	380	389	297	177	181	140
Mean (hours)	8.20 (8.06-8.34)	8.21 (8.06-8.36)	7.89 (7.73-8.04)*	7.98 (7.75-8.21)	8.18 (7.99-8.37)	8.21 (7.98-8.44)
≤6 hrs	9.7 (6.7-12.7)	10.8 (7.7-13.9)	14.8 (10.8-18.9)	13.6 (8.5-18.7)	8.3 (4.2-12.3)	12.1 (6.7-17.6)
7 hrs	16.6 (12.8-20.3)	17.0 (13.2-20.7)	24.6 (19.7-29.5)	27.1 (20.5-33.7)*	15.5 (10.2-20.8)	16.4 (10.2-22.6)
8hrs	35.0 (30.2-39.8)	35.0 (30.2-39.7)	27.3 (22.2-32.4)	23.7 (17.4-30.1)*	40.9 (33.7-48.1)	30.7 (23.0-38.5)
9hrs	26.6 (22.1-31.0)	22.1 (18.0-26.2)	22.2 (17.5-27.0)	19.8 (13.8-25.7)	21.5 (15.5-27.6)	22.9 (15.8-29.9)
≥10hrs	12.1 (8.8-15.4)	15.2 (11.6-18.7)	11.1 (7.5-14.7)	15.8 (10.4-21.2)	13.8 (8.7-18.9)	17.9 (11.4-24.3)

*Significantly different from White UK

^Value at 14-16yrs significantly different to 11-13yrs within ethnic group

(significance determined by non-overlapping confidence intervals)

6.1.2 Parental lifestyles

Pupils were asked about the lifestyles of the parent(s) (or step-parent) they lived with; whether they were overweight and whether they smoked. The measures aimed to capture the pupils' exposure to unhealthy lifestyles in their home environment. Results are summarised for boys in Table 6.8 and girls in Table 6.9.

6.1.2.1 Parental overweight

For both boys and girls there were no statistically significant ethnic differences in the proportion of pupils who reported living with an overweight mother at either 11-13yrs or 14-16yrs. At both ages the Black Caribbean boys were the least likely to live with an overweight mother (5.1% at 11-13yrs, 5.4% at 14-16yrs), and the Pakistani/Bangladeshi girls the most likely (12.1% at 11-13yrs, 20% at 14-16yrs). The girls consistently reported higher levels of living with an overweight mother at 14-16yrs compared to 11-13yrs but this increase was not statistically significant for any group. Some of the boys also reported higher proportions at 14-16yrs (e.g. White UK and Indian) but others reported lower levels (e.g. Nigerian/Ghanaians and Other Africans). Within ethnic group, there were no significant differences between girls and boys in their likelihood of living with an overweight mother at either age, although in every ethnic group girls reported higher levels than boys at 14-16yrs. There were no significant ethnic differences in the proportions who said they did not know if their mother was overweight for either boys or girls. Within ethnic group, at 11-13yrs the Indian girls were significantly more likely than the Indian boys to not know if their mother was overweight; there were no other significant sex differences.

There were significant ethnic differences for resident fathers' overweight. For both boys and girls and at both ages the Black Caribbeans, Nigerian/Ghanaians, and Other Africans were the least likely to report living with an overweight father. The White UK, Indian, and Pakistani/Bangladeshi groups had similar proportions to each other at both ages. In every ethnic group proportions were higher at 14-16yrs than 11-13yrs except the Black Caribbean and Other African boys, but no age differences were statistically significant. There were no differences between the boys and girls in their likelihood of living with an overweight father. There were no significant ethnic, age, or sex differences in the proportions who did not know if their father was overweight.

6.1.2.2 Parental smoking

There were stark ethnic differences in the proportions living with a mother who smoked. At both ages and for both boys and girls, the White UK pupils were significantly more likely than all of the other groups to live with a mother who smoked; over a third of them did so compared to around 5% or less of the Nigerian/Ghanaians, Other Africans, Indians, and Pakistani/Bangladeshis. The Black Caribbeans reported significantly lower levels than the White UK, but significantly higher than the other groups; around 20% of the girls and 24% of the boys. Within ethnic group, proportions were similar at both ages. At 11-13yrs the Other African girls (6.2%) were significantly more likely than the boys (1.1%) to live with a mother who smoked. There were no other significant sex differences within ethnic group.

For both ages and both sexes, the White UK and Pakistani/Bangladeshi pupils were the most likely to report living with a smoking father and the Nigerian/Ghanaians least likely. There were no significant differences by age. Within ethnic group, there were no significant sex differences although at both ages the Nigerian/Ghanaian boys were more likely than the girls to have a resident father who smoked.

The information on mother and father's smoking status was combined; the White UK pupils were the least likely to live in a non-smoking home (around half of them did so) and the Nigerian/Ghanaians most likely (over 80%). Only a minority of the pupils reported that both their mother and father smoked and the majority of them were either White UK or Black Caribbean; this is likely due to the low proportion of mothers smoking in many of the ethnic groups.

Table 6.8 Boys: Parental behaviours by age and ethnicity

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N		490	389	207	209	237	305
Mother (Resident)							
Overweight (%)	11-13	5.7 (3.7-7.8)	5.1 (2.9-7.3)	8.7 (4.8-12.6)	8.1 (4.4-11.9)	5.9 (2.9-8.9)	9.8 (6.5-13.2)
	14-16	7.8 (5.4-10.1)	5.4 (3.1-7.7)	6.3 (2.9-9.6)	6.2 (2.9-9.5)	9.3 (5.6-13.0)	10.2 (6.8-13.6)
Don't Know if overweight (%)	11-13	7.8 (5.4-10.1)	4.6 (2.5-6.7)	8.2 (4.4-12.0)	8.6 (4.8-12.4)	6.8 (3.5-10.0)	9.2 (5.9-12.4)
	14-16	8.4 (5.9-10.8)	5.4 (3.1-7.7)	6.7 (3.3-10.2)	9.6 (5.5-13.6)	8.0 (4.5-11.5)	8.0 (4.5-11.5)
Smoker (%)	11-13	34.9 (30.7-39.1)	20.1 (16.1-24.0)*	1.9 (0.0-3.8)*	6.2 (2.9-9.5)*	1.3 (0.0-2.7)*	2.3 (0.6-4.0)*
	14-16	33.1 (28.9-37.2)	19.8 (15.8-23.8)*	1.4 (0.0-3.1)*	2.9 (0.6-5.1)*	3.0 (0.8-5.1)*	3.6 (1.5-5.7)*
Father (Resident)							
Overweight (%)	11-13	6.3 (4.2-8.5)	2.6 (1.0-4.2)*	1.9 (0.0-3.8)*	3.8 (1.2-6.5)	7.2 (3.9-10.5)	6.9 (4.0-9.7)
	14-16	9.0 (6.4-11.5)	1.8 (0.5-3.1)*	3.4 (0.9-5.9)	2.9 (0.6-5.1)*	9.3 (5.6-13.0)	7.9 (4.8-10.9)
Don't Know if overweight (%)	11-13	6.3 (4.2-8.5)	3.6 (1.7-5.5)	3.9 (1.2-6.5)	3.3 (0.9-5.8)	5.5 (2.6-8.4)	8.2 (5.1-11.3)
	14-16	4.3 (2.5-6.1)	2.6 (1.0-4.2)	3.4 (0.9-5.9)	4.3 (1.5-7.1)	4.2 (1.6-6.8)	6.6 (3.8-9.4)
Smoker (%)	11-13	30.8 (26.7-34.9)	23.4 (19.2-27.6)	3.4 (0.9-5.9)*	15.8 (10.8-20.8)*	17.7 (12.8-22.6)*	30.5 (25.3-35.7)
	14-16	26.9 (23.0-30.9)	15.7 (12.1-19.3)*	5.3 (2.2-8.4)*	11.0 (6.7-15.3)*	18.1 (13.2-23.1)	27.5 (22.5-32.6)
Not resident							
Mother (%)	11-13	3.3 (1.7-4.8)	6.2 (3.8-8.6)	3.9 (1.2-6.5)	7.2 (3.6-10.7)	1.3 (0.0-2.7)	2.6 (0.8-4.4)
	14-16	3.7 (2.0-5.3)	7.7 (5.0-10.4)	4.8 (1.9-7.8)	12.4 (7.9-17.0)*	2.5 (0.5-4.5)	3.0 (1.0-4.9)
Father (%)	11-13	21.6 (18.0-25.3)	42.7 (37.7-47.6)*	31.4 (25.0-37.8)	38.8 (32.1-45.4)*	4.6 (1.9-7.3)*	11.5 (7.9-15.1)*
	14-16	25.1 (21.2-29.0)	49.9 (44.9-54.9)*	36.2 (29.6-42.8)*	45.5 (38.6-52.3)*	9.3 (5.6-13.0)*	13.8 (9.9-17.7)*

*Significantly different from White UK

^Value at 14-16yrs significantly different to 11-13yrs within ethnic group

(significance determined by non-overlapping confidence intervals)

Table 6.9 Girls: Parental behaviours by age and ethnicity

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N		380	389	297	177	181	140
Mother (Resident)							
Overweight (%)	11-13	6.6 (4.1-9.1)	9.5 (6.6-12.4)	8.1 (5.0-11.2)	7.9 (3.9-11.9)	9.4 (5.1-13.7)	12.1 (6.7-17.6)
	14-16	11.3 (8.1-14.5)	10.5 (7.5-13.6)	12.8 (9.0-16.6)	11.3 (6.6-16.0)	13.3 (8.3-18.2)	20.0 (13.3-26.7)
Don't Know if overweight (%)	11-13	11.6 (8.3-14.8)	8.7 (5.9-11.6)	11.1 (7.5-14.7)	9.6 (5.2-14.0)	16.0 (10.6-21.4)	16.4 (10.2-22.6)
	14-16	5.8 (3.4-8.1)^	5.4 (3.1-7.7)	6.4 (3.6-9.2)	6.2 (2.6-9.8)	8.8 (4.7-13.0)	6.4 (2.3-10.5)
Smoker (%)	11-13	38.4 (33.5-43.3)	24.2 (19.9-28.4)*	2.0 (0.4-3.6)*	1.1 (0.0-2.7)*	1.7 (0.0-3.5)*	0.7 (0.0-2.1)*
	14-16	38.7 (33.8-43.6)	24.2 (19.9-28.4)*	3.4 (1.3-5.4)*	2.3 (0.0-4.5)*	1.7 (0.0-3.5)*	2.1 (0.0-4.6)*
Father (Resident)							
Overweight (%)	11-13	7.4 (4.7-10.0)	1.8 (0.5-3.1)*	2.7 (0.8-4.5)*	2.3 (0.0-4.5)*	5.5 (2.2-8.9)	8.6 (3.9-13.3)
	14-16	10.3 (7.2-13.3)	3.1 (1.4-4.8)	4.4 (2.0-6.7)	5.6 (2.2-9.1)	9.9 (5.5-14.3)	9.3 (4.4-14.2)
Don't Know if overweight (%)	11-13	8.2 (5.4-10.9)	4.9 (2.7-7.0)	4.7 (2.3-7.1)	6.2 (2.6-9.8)	9.4 (5.1-13.7)	10.7 (5.5-15.9)
	14-16	4.2 (2.2-6.2)	2.6 (1.0-4.2)	3.7 (1.5-5.9)	0.6 (0.0-1.7)	7.2 (3.4-11.0)	4.3 (0.9-7.7)
Smoker (%)	11-13	28.9 (24.4-33.5)	23.1 (18.9-27.3)	9.1 (5.8-12.4)*	14.1 (8.9-19.3)*	20.4 (14.5-26.4)	33.6 (25.7-41.5)
	14-16	25.5 (21.1-29.9)	15.4 (11.8-19.0)*	10.1 (6.7-13.5)*	9.6 (5.2-14.0)*	18.8 (13.0-24.5)	27.1 (19.7-34.6)
Not resident							
Mother (%)	11-13	2.9 (1.2-4.6)	7.5 (4.8-10.1)*	3.7 (1.5-5.9)	6.8 (3.0-10.5)	1.7 (0.0-3.5)	2.9 (0.1-5.7)
	14-16	3.9 (2.0-5.9)	8.5 (5.7-11.3)	4.4 (2.0-6.7)	7.3 (3.5-11.2)	2.2 (0.0-4.4)	2.9 (0.1-5.7)
Father (%)	11-13	26.6 (22.1-31.0)	54.5 (49.5-59.5)*	27.6 (22.5-32.7)*	42.9 (35.6-50.3)*	7.2 (3.4-11.0)*	9.3 (4.4-14.2)*
	14-16	29.5 (24.9-34.1)	62.7 (57.9-67.6)*	32.7 (27.3-38.0)	51.4 (44.0-58.8)*	10.5 (6.0-15.0)*	16.4 (10.2-22.6)*

*Significantly different from White UK

^Value at 14-16yrs significantly different to 11-13yrs within ethnic group

(significance determined by non-overlapping confidence intervals)

6.1.3 Family socio-economic circumstances

The DASH questionnaires contained several items which aimed to capture the socio-economic circumstances of the pupils' families: standard of living items, overcrowding, parental employment and family type. Sex, age and ethnic differences in these will be discussed in turn (results presented in Table 6.10 for boys and Table 6.11 for girls). Ethnic differences in family SES at 11-13yrs have previously been reported (Harding et al., 2008b). This thesis extends the previous analyses to examine differences at 14-16yrs and to investigate how the different family SES measures relate to one another and to measures of school and neighbourhood deprivation.

6.1.3.1 Standard of living items

At both 11-13yrs and 14-16yrs the White UK and Indian pupils were the most likely to be in the least deprived quartile (Q1) and the least likely to be in the most deprived quartile (Q4), however ethnic differences were generally less for Q4 compared to Q1. The Other African and Pakistani/Bangladeshi boys were significantly more likely than the White UK boys to be in the most deprived quartile at 11-13yrs but not at 14-16yrs. This was due to the proportions in this category declining more for the ethnic minority groups than for the White UK boys. For the girls, the Black Caribbeans and Nigerian/Ghanaians were significantly more likely to be in the most deprived quartile than the White UK girls at both ages. The Other African and Pakistani/Bangladeshi girls were significantly more likely at 11-13yrs only.

All of the sex and ethnic groups were more likely to be in Q1 (least deprived) at 14-16yrs than 11-13yrs, with this increase being significant for many groups: the White UK boys and girls; Other African boys; Indian boys and girls; and Pakistani/Bangladeshi boys and girls. Similarly, all of the groups experienced a decline in the proportion being in Q4 (most deprived) at 14-16yrs compared to 11-13yrs. This decline was statistically significant for all of the groups except for the White UK boys.

Two of the standard of living items were examined in more detail as they were hypothesised to be the most likely to have an association with physical activity, and hence body size: car/van ownership and private garden. Proportions owning a car/van were high (around 70% or above for every group) and similar at both ages. For the boys at both ages, the Indians had significantly higher car ownership than all of the other groups (except the Pakistani/Bangladeshis at 14-16yrs). For girls, Black Caribbeans at both ages, and Other

Africans at 11-13yrs, had significantly lower car/van ownership than the White UK, Nigerian/Ghanaian, and Indian girls.

The proportion of pupils reporting having a private garden at home showed more ethnic variation than car ownership. The ethnic pattern at both time points and for both sexes was similar. The Indian pupils reported the highest levels of private gardens at close to or above 90%. The Pakistani/Bangladeshis and White UK pupils also reported high levels (all above 80%). Proportions were lower for the Nigerian/Ghanaians and Other Africans; generally around or below 60%. The Nigerian/Ghanaian girls at 11-13yrs reported the lowest proportion of all; just over half (51.5%) reported that their home had a private garden.

6.1.3.2 Overcrowding

For overcrowding, the overall pattern of ethnic differences was similar at both ages and for both sexes. The White UK pupils generally had the lowest levels of overcrowding followed by the Indians. The Other African and Pakistani/Bangladeshi pupils tended to have the highest levels. At both ages, the Nigerian/Ghanaian, Other African, and Pakistani/Bangladeshi boys and girls had significantly higher levels of overcrowding than the White UK pupils. The Black Caribbean boys and girls, and the Indian girls, had significantly higher levels at 11-13yrs only.

Although ethnic patterns were similar for boys and girls, there was a notable gender difference for the Indian group; at 11-13yrs 18% of the Indian girls lived in overcrowded homes compared to 10% of the Indian boys (the Indians at this age were also the group to show the largest sex difference in the standard of living items). There was little difference in overcrowding between the girls and boys; overall at 11-13yrs 18.8% (95% CI: 17.0%-20.6%) of the boys and 19.2% (17.2%-21.1%) of the girls lived in overcrowded homes. The proportion was significantly lower at 14-16yrs for both genders; 12.5% (11.0%-14.0%) of the boys and 12.4% (10.8%-14.0%) of the girls. A decline in overcrowding was seen in every ethnic group, ranging from a drop of 1.2 percentage points for the White UK boys to 11.6 percentage points for the Nigerian/Ghanaian boys. This decline was statistically significant for the Nigerian/Ghanaian boys and girls, and the Black Caribbean girls.

6.1.3.3 Family type and parental employment

There were ethnic differences in the prevalence of one-parent families. The magnitude and statistical significance of these ethnic differences varied somewhat by sex and age but the overall pattern was the same. The Indian and Pakistani/Bangladeshi pupils were the least likely to be in a one-parent family, and the Black Caribbeans the most likely. At both ages, the girls were significantly more likely than the boys to be in a one-parent family; 30.9% (28.6%-33.2%) of the girls and 24.8% (22.8%-26.8%) of the boys were in one-parent families at 11-13yrs. The proportions were significantly higher at 14-16yrs and the sex difference remained: girls 37.1% (34.7%-39.5%); boys 30.3% (28.2-32.4%).

The Other Africans and Pakistani/Bangladeshis were the most likely to have no parent working. The difference between the Other Africans and Pakistani/Bangladeshis and the other groups was greater for the girls than for the boys, due to parental unemployment rates in the Other Africans and Pakistani/Bangladeshis being higher for the girls than the boys. There was a consistently large difference in parental employment between the Nigerian/Ghanaians and Other Africans; the Other Africans were considerably more deprived with regards to this measure.

As family type and parental employment are related (in that you have more chance to have a working parent if you have two resident parents as opposed to one), these variables were combined. The majority of pupils lived in two-parent working households, however there were ethnic differences. The Black Caribbean and Other African boys and girls were significantly less likely to be in a two-parent working family that the other ethnic groups at both ages. The Indian girls at both ages, and boys at 14-16yrs, were significantly more likely to be in this family type than any of the other groups. A sizeable proportion of the Black Caribbean pupils were in one-parent working families, whereas very few of the Indian and Pakistani/Bangladeshi pupils were in such families. The proportion of pupils in two-parent not working families was considerably higher for the Pakistani/Bangladeshis than most of the other groups; in particular the Nigerian/Ghanaian and Black Caribbeans had only a very small proportion of pupils in this category.

Further analysis was undertaken to determine the relationship between the family type and parental employment measures and if this differed by ethnicity. In every ethnic group a higher proportion of 2 parent families were working compared to 1 parent families (Figure 6.1). However the likelihood of a one-parent household being a working one differed by ethnicity. Both the Other Africans and Black Caribbeans had high proportions of lone parent families, but these were significantly more likely to be working for the Black Caribbeans (over 60%) than the Other Africans (less than 40%). Therefore, the impact of being in a one-parent family in terms of affluence/deprivation is also likely to differ by ethnic group.

Figure 6.1 Percentage of pupils with one or more resident working parents by gender, ethnicity and family type

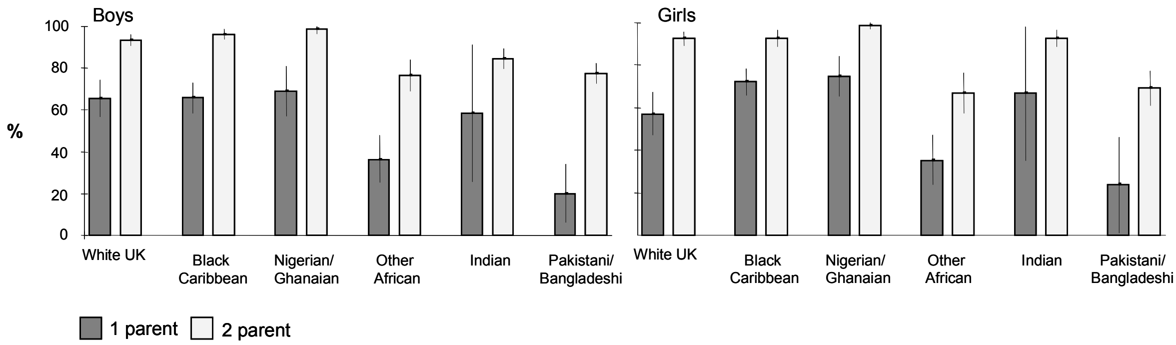


Table 6.10 Boys: Family socio-economic circumstances by age and ethnicity

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N		490	389	207	209	237	305
Standard of living items							
Mean no. items	11-13	15.4 (15.2-15.6)	14.8 (14.6-15.0)*	14.4 (14.1-14.7)*	14.1 (13.7-14.4)*	15.4 (15.1-15.7)	14.5 (14.3-14.8)*
	14-16	16.1 (15.9-16.2)^	15.5 (15.4-15.7)*^	15.3 (15.0-15.5)*^	15.2 (14.9-15.5)*^	16.2 (16.0-16.5)^	15.7 (15.5-15.9)*^
Q1 (least deprived)	11-13	35.1 (30.9-39.3)	24.2 (19.9-28.4)*	14.5 (9.7-19.3)*	14.4 (9.6-19.1)*	32.9 (26.9-38.9)	18.0 (13.7-22.4)*
	14-16	48.6 (44.1-53.0)^	30.8 (26.2-35.5)*	22.2 (16.5-27.9)*	25.4 (19.4-31.3)^*	47.7 (41.3-54.1)^	33.8 (28.4-39.1)^*
Q2	11-13	19.2 (15.7-22.7)	20.1 (16.1-24.0)	20.8 (15.2-26.3)	14.8 (10.0-19.7)	21.5 (16.2-26.8)	18.7 (14.3-23.1)
	14-16	18.4 (14.9-21.8)	25.7 (21.3-30.1)	20.3 (14.8-25.8)	23.0 (17.2-28.7)	24.5 (19.0-30.0)	25.2 (20.3-30.1)
Q3	11-13	26.1 (22.2-30.0)	29.8 (25.3-34.4)	36.2 (29.6-42.8)	33.5 (27.0-39.9)	27.0 (21.3-32.7)	34.8 (29.4-40.1)
	14-16	19.8 (16.3-23.3)	28.0 (23.5-32.5)*	44.4 (37.6-51.3)*	34.0 (27.5-40.4)*	20.7 (15.5-25.9)	30.5 (25.3-35.7)
Q4 (most deprived)	11-13	19.6 (16.1-23.1)	26.0 (21.6-30.3)	28.5 (22.3-34.7)	37.3 (30.7-43.9)*	18.6 (13.6-23.6)	28.5 (23.4-33.6)*
	14-16	13.3 (10.3-16.3)	15.4 (11.8-19.0)^	13.0 (8.4-17.7)^	17.7 (12.5-22.9)^	7.2 (3.9-10.5)	10.5 (7.0-14.0)^
Private garden at home (%)	11-13	82.7 (79.3-86.0)	69.2 (64.5-73.8)*	55.6 (48.7-62.4)*	52.6 (45.8-59.5)*	91.6 (88.0-95.1)*	83.6 (79.4-87.8)
	14-16	82.4 (79.1-85.8)	73.8 (69.4-78.2)*	56.0 (49.2-62.9)*	64.1 (57.6-70.7)*	92.4 (89.0-95.8)*	86.6 (82.7-90.4)
Family own car/van (%)	11-13	80.4 (76.9-83.9)	78.7 (74.6-82.8)	79.7 (74.2-85.2)	72.2 (66.1-78.4)	89.9 (86.0-93.7)*	85.9 (82.0-89.8)
	14-16	79.8 (76.2-83.4)	79.2 (75.1-83.2)	79.7 (74.2-85.2)	74.6 (68.7-80.6)	89.5 (85.5-93.4)*	89.8 (86.4-93.2)*
Family type / parental employment							
2 parent, ≥1 working (%)	11-13	71.2 (67.2-75.2)	52.4 (47.5-57.4)*	66.7 (60.2-73.1)	45.5 (38.6-52.3)*	79.7 (74.6-84.9)	67.5 (62.3-72.8)
	14-16	67.1 (63.0-71.3)	42.9 (38.0-47.9)*	60.9 (54.2-67.6)	38.8 (32.1-45.4)*	80.6 (75.5-85.7)*	68.2 (62.9-73.5)
1 parent, working (%)	11-13	14.7 (11.5-17.8)	27.8 (23.3-32.2)*	20.3 (14.8-25.8)	12.9 (8.3-17.5)	3.0 (0.8-5.1)*	2.3 (0.6-4.0)*
	14-16	18.4 (14.9-21.8)	35.0 (30.2-39.7)*	23.2 (17.4-29.0)	15.8 (10.8-20.8)	5.5 (2.6-8.4)*	4.3 (2.0-6.5)*
2 parent, neither working (%)	11-13	5.1 (3.1-7.1)	2.1 (0.6-3.5)	1.0 (0.0-2.3)*	13.9 (9.2-18.6)*	14.8 (10.2-19.3)*	19.7 (15.2-24.2)*
	14-16	4.9 (3.0-6.8)	3.1 (1.4-4.8)	1.0 (0.0-2.3)*	12.0 (7.5-16.4)*	8.0 (4.5-11.5)	16.4 (12.2-20.6)*
1 parent, not working (%)	11-13	7.8 (5.4-10.1)	14.4 (10.9-17.9)*	9.2 (5.2-13.1)	22.5 (16.8-28.2)*	2.1 (0.3-4.0)*	9.2 (5.9-12.4)
	14-16	8.8 (6.3-11.3)	15.4 (11.8-19.0)*	12.1 (7.6-16.6)	24.9 (19.0-30.8)*	5.5 (2.6-8.4)	9.8 (6.5-13.2)
Other family type	11-13	1.2 (0.2-2.2)	3.3 (1.5-5.1)	2.9 (0.6-5.2)	5.3 (2.2-8.3)*	0.4 (0.0-1.3)	1.3 (0.0-2.6)
	14-16	0.8 (0.0-1.6)	3.6 (1.7-5.5)*	2.9 (0.6-5.2)	8.6 (4.8-12.4)*	0.4 (0.0-1.3)	1.3 (0.0-2.6)

Overcrowding							
Home is overcrowded (%)	11-13	8.0 (5.6-10.4)	15.7 (12.1-19.3)*	29.0 (22.8-35.2)*	33.5 (27.0-39.9)*	10.1 (6.3-14.0)	29.8 (24.7-35.0)*
	14-16	6.7 (4.5-9.0)	9.5 (6.6-12.4)	17.4 (12.2-22.6)*^	23.4 (17.7-29.2)*	4.6 (1.9-7.3)	21.0 (16.4-25.6)*

* Significantly different from White UK

^ Value at 14-16yrs significantly different to 11-13yrs within ethnic group

(significance determined by non-overlapping confidence intervals)

Table 6.11 Girls: Socio-economic circumstances by age and ethnicity

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N		380	389	297	177	181	140
Standard of living items							
Mean no. items	11-13	15.5 (15.3-15.7)	14.6 (14.4-14.8)*	14.3 (14.0-14.5)*	14.0 (13.7-14.4)*	14.8 (14.5-15.2)*	13.9 (13.6-14.3)*
	14-16	16.3 (16.1-16.4)^	15.2 (15.0-15.4)*^	15.1 (14.9-15.3)*^	15.0 (14.8-15.3)*^	16.3 (16.1-16.6)^	15.5 (15.2-15.8)*^
Q1 (least deprived)	11-13	37.1 (32.2-42.0)	22.1 (18.0-26.2)*	14.5 (10.5-18.5)*	13.6 (8.5-18.7)*	23.8 (17.5-30.0)*	13.6 (7.8-19.3)*
	14-16	50.8 (45.7-55.8)^	27.5 (23.0-32.0)	19.2 (14.7-23.7)*	19.2 (13.3-25.1)*	50.3 (42.9-57.6)^	28.6 (21.0-36.1)^*
Q2	11-13	16.1 (12.3-19.8)	18.5 (14.6-22.4)	13.1 (9.3-17.0)	16.4 (10.9-21.9)	19.3 (13.5-25.1)	14.3 (8.4-20.2)
	14-16	18.4 (14.5-22.3)	17.2 (13.5-21.0)	18.5 (14.1-23.0)	22.6 (16.4-28.8)	22.7 (16.5-28.8)	20.0 (13.3-26.7)
Q3	11-13	29.7 (25.1-34.4)	30.6 (26.0-35.2)	41.4 (35.8-47.0)*	33.9 (26.9-40.9)	33.7 (26.7-40.7)	33.6 (25.7-41.5)
	14-16	22.4 (18.2-26.6)	35.0 (30.2-39.7)*	46.8 (41.1-52.5)*	41.8 (34.5-49.1)	21.5 (15.5-27.6)	41.4 (33.2-49.7)*
Q4 (most deprived)	11-13	17.1 (13.3-20.9)	28.8 (24.3-33.3)*	31.0 (25.7-36.3)*	36.2 (29.0-43.3)*	23.2 (17.0-29.4)	38.6 (30.4-46.7)*
	14-16	8.4 (5.6-11.2)^	20.3 (16.3-24.3)*	15.5 (11.3-19.6)^*	16.4 (10.9-21.9)^	5.5 (2.2-8.9)^	10.0 (5.0-15.0)^
Private garden at home (%)	11-13	81.6 (77.7-85.5)	67.1 (62.4-71.8)*	51.5 (45.8-57.2)*	59.3 (52.0-66.6)*	89.5 (85.0-94.0)	84.3 (78.2-90.4)
	14-16	83.4 (79.7-87.2)	69.7 (65.1-74.3)*	59.6 (54.0-65.2)*	61.6 (54.3-68.8)*	91.7 (87.7-95.8)*	88.6 (83.2-93.9)
Family own car/van (%)	11-13	84.5 (80.8-88.1)	69.2 (64.5-73.8)*	83.8 (79.6-88.0)	71.8 (65.1-78.4)*	85.1 (79.8-90.3)	80.7 (74.1-87.3)
	14-16	85.5 (82.0-89.1)	72.5 (68.0-77.0)*	84.2 (80.0-88.3)	78.5 (72.4-84.6)	87.8 (83.0-92.7)	82.1 (75.7-88.6)
Family type / parental employment							
2 parent, ≥1 working (%)	11-13	66.8 (62.1-71.6)	39.6 (34.7-44.5)*	69.4 (64.1-74.6)	37.3 (30.1-44.5)*	85.6 (80.5-90.8)*	60.7 (52.5-68.9)
	14-16	63.9 (59.1-68.8)	32.1 (27.5-36.8)*	63.0 (57.4-68.5)	37.3 (30.1-44.5)*	80.7 (74.9-86.5)*	55.0 (46.7-63.3)
1 parent, working (%)	11-13	14.7 (11.2-18.3)	38.0 (33.2-42.9)*	20.9 (16.2-25.5)	13.6 (8.5-18.7)	4.4 (1.4-7.4)*	2.9 (0.0-5.7)*
	14-16	17.6 (13.8-21.5)	45.8 (40.8-50.7)*	24.6 (19.7-29.5)	15.3 (9.9-20.6)	8.8 (4.7-13.0)*	4.3 (0.9-7.7)*
2 parent, neither working (%)	11-13	5.5 (3.2-7.8)	3.1 (1.4-4.8)	1.0 (0.0-2.2)*	18.6 (12.9-24.4)*	6.6 (3.0-10.3)	27.1 (19.7-34.6)*
	14-16	4.7 (2.6-6.9)	1.5 (0.3-2.8)	1.3 (0.0-2.7)	10.2 (5.7-14.7)	7.2 (3.4-11.0)	26.4 (19.0-33.8)*
1 parent, not working (%)	11-13	11.1 (7.9-14.2)	14.7 (11.1-18.2)	7.1 (4.1-10.0)*	24.9 (18.4-31.2)*	2.2 (0.0-4.4)*	9.3 (4.4-14.2)
	14-16	11.6 (8.3-14.8)	15.7 (12.1-19.3)	9.8 (6.4-13.2)	31.1 (24.2-38.0)*	2.8 (0.0-5.2)*	13.6 (7.8-19.3)
Other family type	11-13	1.8 (0.4-3.2)	4.6 (2.5-6.7)	1.7 (0.2-3.2)	5.6 (2.2-9.1)	1.1 (0.0-2.6)	0
	14-16	2.1 (0.7-3.6)	4.9 (2.7-7.0)	1.3 (0.0-2.7)	6.2 (2.6-9.8)	0.6 (0.0-1.6)	0.7 (0.0-2.1)

Overcrowding							
Home is overcrowded (%)	11-13	8.2 (5.4-10.9)	14.9 (11.4-18.5)*	26.6 (21.5-31.7)*	31.6 (24.7-38.6)*	17.7 (12.1-23.3)*	31.4 (23.6-39.2)*
	14-16	5.5 (3.2-7.8)	8.2 (5.5-11.0)^	16.5 (12.3-20.7)*^	22.6 (16.4-28.8)*	9.4 (5.1-13.7)	25.0 (17.7-32.3)*

* Significantly different from White UK

^ Value at 14-16yrs significantly different to 11-13yrs within ethnic group

(significance determined by non-overlapping confidence intervals)

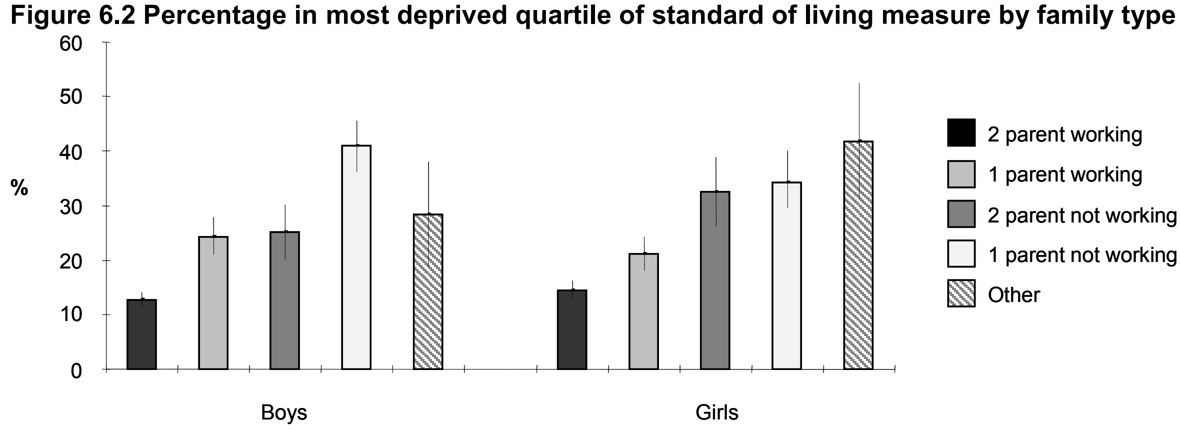
6.1.3.4 Comparison of SES measures

As a test of the validity of the pupil-reported family SES measures, the variables were cross-tabulated with one another to determine whether those classified as disadvantaged by one measure were also classified as disadvantaged by another measure. Correspondence between the different SES measures would suggest that they were managing to capture those pupils who were most disadvantaged, although it is acknowledged that each of the family level SES measures captured a different facet of disadvantage and therefore disagreement between them would be expected. Family level SES (as measured by standard of living items) was also compared to the neighbourhood and school measures of SES described in previous chapters; the aim was to determine if pupils classed as most disadvantaged by the (self-reported) family SES measure were the ones living in the most deprived areas and attending the most deprived schools (both of which were objectively measured).

Comparison of family measures of SES

A series of chi-squared tests were conducted to determine the relationship between two of the individual measures of deprivation; standard of living items and family type/parental employment status. For both boys and girls, those living in two parent working families were the most likely to be in the least disadvantaged standard of living quartile, and conversely the least likely to be in the most deprived quartile (Figure 6.2). This pattern was observed within each group except for the Other African boys and girls; there was no significant association between standard of living items and family type/employment status for this ethnic group.

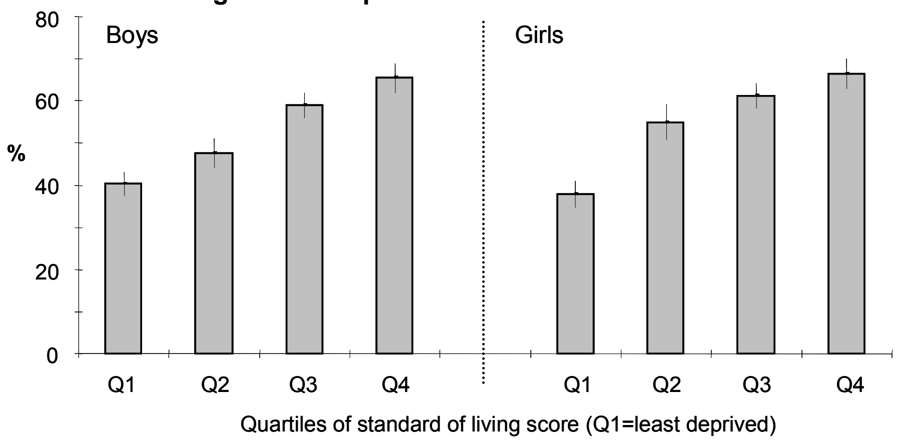
Figure 6.2 Percentage in most deprived quartile of standard of living measure by family type



Comparison of family and neighbourhood SES

There was a trend across the quartiles of standard of living measure, with those in the most deprived quartile (Q4) being the most likely to live in the most deprived neighbourhoods (IMD Q5) (Figure 6.3). However a substantial proportion (around 40%) of those in the most affluent standard of living quartile (Q1) lived in the most deprived areas; this reflects the fact that a large proportion of the DASH pupils lived in deprived areas. The trend across the quartiles was observed within all groups except the Other African boys and girls (for the girls, those from the least deprived families were actually the most likely to live in the most deprived quintile). For the Pakistani/Bangladeshi pupils there was less of a trend than observed for the other groups.

Figure 6.3 Percentage of pupils living in the most deprived neighbourhoods (IMD Q5) by standard of living measure quartiles

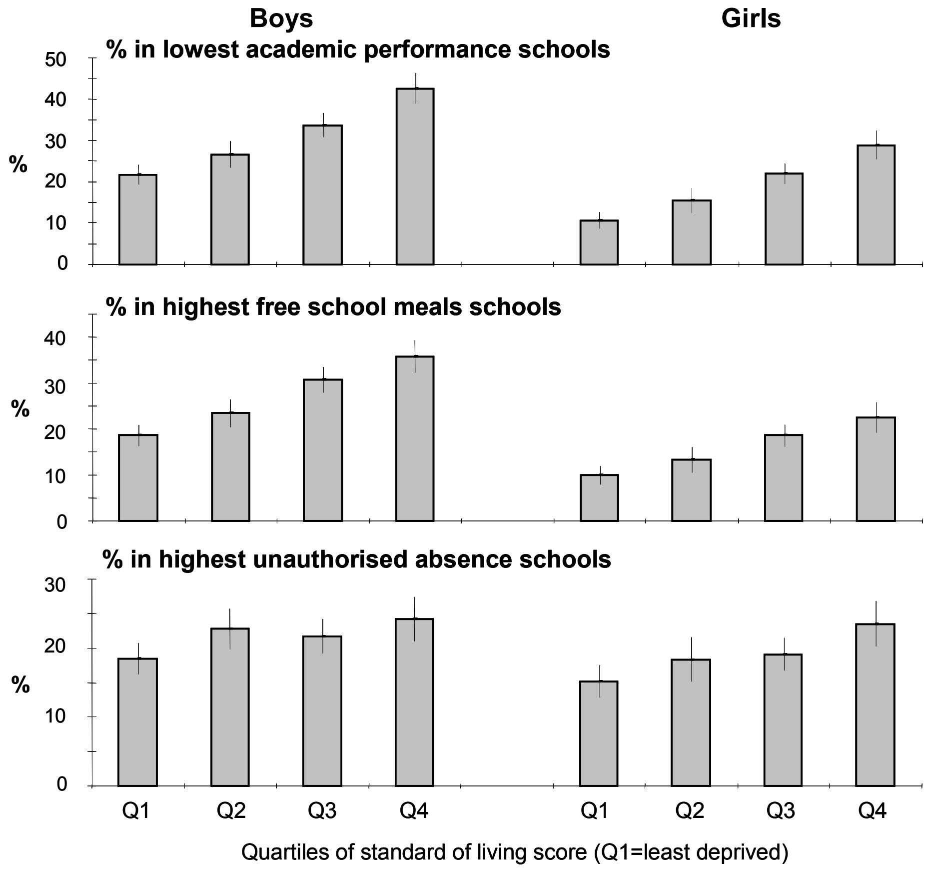


Comparison of family and school level SES measures

For both boys and girls, there was a linear trend across the standard of living quartiles in the likelihood of attending a school in the lowest academic quartile; the most deprived pupils were the most likely to attend a low achieving school (Figure 6.4). This pattern was observed within most groups, exceptions being the Other African boys and girls for whom there was no association between individual and school SES. The Indian girls also did not show this trend; high proportions of pupils in every deprivation quartile attended schools in the top two quartiles of academic performance (Q1 or Q2). The most deprived Pakistani/Bangladeshi boys and girls were the most likely to attend a low achieving school, however there was not a trend across the categories to the same extent as that observed for the other groups.

A similar trend was observed when Free School Meals was used as the measure of school deprivation. Pupils from the most deprived families were the most likely to attend schools with the highest proportion of pupils receiving free school meals; within group, this pattern was observed with the exception of the Indians and Pakistani/Bangladeshis. Boys and girls in the least deprived standard of living measures quintile were the least likely to attend a school with high absenteeism rates, while those in the highest deprivation category were the most likely to attend such schools. However there was not a clear trend across the quartiles as was observed for academic performance and free school meals.

Figure 6.4 Percentage of pupils attending the most deprived schools by standard of living measure quartiles



6.1.4 Acculturation

A pupil's acculturation level could indicate the extent to which they are exposed to cultural norms and values; these could influence attitudes to healthy eating and exercise, and consequently health behaviours. Four measures of pupils' acculturation were investigated: generational status; ethnicity of friends; language use; and attendance at a place of worship. Age, sex and ethnic differences in these are discussed in turn and results are presented for boys in Table 6.12 and girls in Table 6.13.

6.1.4.1 Generational Status

Unsurprisingly, the White UK pupils were the least likely to have been born abroad. The majority of the Black Caribbean, Nigerian/Ghanaian, Indian, and Pakistani/Bangladeshi pupils were born in the UK; roughly 20% of each of these groups reported that they had been born abroad. The Other African pupils were the most likely to have been born abroad; 53.1% of the Other African boys and 56.5% of the Other African girls.

6.1.4.2 Ethnicity of friends

Pupils reported how many of their friends were a different ethnicity to themselves. There were ethnic differences; the Black Caribbean pupils were the least likely to report having most or all friends a different ethnicity to themselves at both ages; at 11-13yrs the Black Caribbean girls (4.6%) were significantly less likely to report this than all of the other girls. In contrast, 22% of the Other African girls at this age reported that most or all of their friends were a different ethnicity to themselves, significantly higher than the White UK, Black Caribbean, and Nigerian/Ghanaian girls. At 14-16yrs there were no significant ethnic differences for the girls; for the boys, the Other Africans (19.6%) and Indians (18.6%) were significantly more likely to report this than the White UK or Black Caribbeans.

There were also ethnic differences in proportions having some or no friends of different ethnicity; at 14-16yrs the Black Caribbean girls were significantly more likely, and the Indian girls significantly less likely, than the White UK girls to report this. For the boys, the Other Africans were significantly less likely at both time points to report this than the White UK boys; the Nigerian/Ghanaian boys were also significantly less likely at 11-13yrs, and the Indian boys at 14-16yrs.

Reporting of friends' ethnicity generally did not vary by sex. There was only one statistically significant age difference; the Indian boys were more likely to say that most of their friends were a different ethnicity to themselves at 14-16yrs (18.6%) than 11-13yrs (6.8%). The Indian girls showed a similar pattern; 22.7% at 14-16yrs, 13.3% at 11-13yrs. Many of the pupils (over 40% of every sex and ethnic group) reported that 'quite a lot' of their friends were from a different ethnic group to themselves; however similar proportions reported that ‘some or none’ were from a different ethnic group. Relatively few reported that ‘most or all’ were a different ethnicity to themselves.

6.1.4.3 Language Use

Very few of the White UK pupils reported that any language other than English was spoken at home; proportions were significantly higher in every other group. Almost all of the Pakistani/Bangladeshi pupils reported that they spoke another language at home (94.8% of the boys and 97.9% of the girls at 11-13yrs). The majority of the Nigerian/Ghanaian, Other African, and Indian pupils also reported speaking an additional language at home (over 60% in all of these groups). The proportion was much lower for the Black Caribbeans; ranging from 23.4% (boys at 11-13yrs) to 36.0% (girls at 14-16yrs). Differences by age and sex were relatively small, but in general the pupils were more likely to report speaking an additional language at home at 14-16yrs than 11-13yrs.

6.1.4.4 Attendance at a place of worship

There were large differences between the ethnic groups in frequency of attendance at a place of worship. Very few of the White UK pupils reported attending a place of worship once a week or more (9% of the girls and 6% of the boys at 11-13yrs, with similar proportions at 14-16yrs). The proportion was significantly higher for all of the other ethnic groups. For the boys, weekly attendance was most common for the Nigerian/Ghanaians and Pakistani/Bangladeshis (around 75% for both groups); for the girls the Nigerian/Ghanaians were the most likely to report weekly or more frequent attendance at both ages (86.2% at 11-13yrs, 78.5% at 14-16yrs). The majority of the White UK pupils reported that they never attended a place of worship. Of the boys, the Pakistani/Bangladeshis and Nigerian/Ghanaians had the lowest proportions reporting never attending; for girls it was the Nigerian/Ghanaians.

There were no significant differences by age for the boys, but there were for the girls; the Indian and Pakistani/Bangladeshi girls were significantly less likely to attend ≥1 per week at 14-16yrs compared to 11-13yrs. The largest difference by sex was observed for the Pakistani/Bangladeshi group; the proportion of girls reporting weekly or more frequent attendance was much lower than the boys and a sizeable proportion of the girls reported never attending.

6.1.4.5 Association between generational status and the other measures of acculturation

A series of chi-squared tests were conducted to determine if generational status was associated with language use, religious attendance, or ethnicity of friends. Language use was significantly associated with generational status for the Black Caribbean, Nigerian/Ghanaian, and Other African girls and boys; in all cases those born abroad were more likely to speak a language in addition to English than those born in the UK.

The association between ethnicity of friends and generational status was significant for the Indian and Pakistani/Bangladeshi girls; those born abroad were less likely to say that most of their friends were a different ethnicity, and more likely to say that some or none were a different ethnicity to themselves. It was also significant for the Indian boys; those born abroad were more likely to say most of their friends were a different ethnicity and less likely to say that quite a lot were a different ethnicity.

Generational status was associated with religious attendance for the Other African and Indian boys; in both cases those born abroad were more likely to attend frequently. A similar pattern was observed in the other groups except for the Pakistani/Bangladeshis. For girls, Indian girls born abroad were more likely to attend frequently than those born in the UK. No association was observed for the other groups.

Table 6.12 Boys: Measures of Accuturation by age and ethnicity

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N		490	389	207	209	237	305
Generational Status							
Born Abroad / <10yrs in UK (%)	11-13	4.5 (2.6-6.3)	21.3 (17.2-25.4)*	23.7 (17.8-29.5)*	53.1 (46.3-59.9)*	17.7 (12.8-22.6)*	18.4 (14.0-22.7)*
Friends of same ethnicity as self							
Most or all (%)	11-13	25.9 (22.0-29.8)	32.6 (28.0-37.3)	29.5 (23.2-35.7)	25.4 (19.4-31.3)	27.4 (21.7-33.1)	25.2 (20.3-30.1)
	14-16	26.7 (22.8-30.7)	33.4 (28.7-38.1)	26.1 (20.1-32.1)	13.4 (8.7-18.1)*^	26.6 (20.9-32.2)	31.8 (26.5-37.1)
Quite a lot (%)	11-13	38.0 (33.6-42.3)	36.5 (31.7-41.3)	33.3 (26.9-39.8)	28.7 (22.5-34.9)	33.8 (27.7-39.8)	44.3 (38.7-49.9)
	14-16	41.4 (37.1-45.8)	38.6 (33.7-43.4)	41.5 (34.8-48.3)	43.5 (36.8-50.3)^	40.9 (34.6-47.2)	45.9 (40.3-51.5)
Some or none (%)	11-13	36.1 (31.9-40.4)	30.8 (26.2-35.5)	37.2 (30.6-43.8)	45.9 (39.1-52.7)	38.8 (32.6-45.1)	30.5 (25.3-35.7)
	14-16	31.8 (27.7-36.0)	28.0 (23.5-32.5)	32.4 (25.9-38.8)	43.1 (36.3-49.8)*	32.5 (26.5-38.5)	22.3 (17.6-27.0)*
Friends of different ethnicity to self							
Most or all (%)	11-13	6.7 (4.5-9.0)	5.4 (3.1-7.7)	13.5 (8.8-18.2)	12.0 (7.5-16.4)	6.8 (3.5-10.0)	10.5 (7.0-14.0)
	14-16	9.8 (7.2-12.4)	5.9 (3.6-8.3)	15.0 (10.1-19.9)	19.6 (14.2-25.0)*	18.6 (13.6-23.6)*^	14.1 (10.2-18.0)
Quite a lot (%)	11-13	40.4 (36.0-44.8)	41.6 (36.7-46.6)	47.3 (40.5-54.2)	51.2 (44.4-58.0)	49.4 (43.0-55.8)	43.9 (38.3-49.5)
	14-16	44.1 (39.7-48.5)	41.1 (36.2-46.0)	48.3 (41.4-55.2)	53.6 (46.8-60.4)	50.2 (43.8-56.6)	48.2 (42.6-53.8)
Some or none (%)	11-13	52.9 (48.4-57.3)	53.0 (48.0-57.9)	39.1 (32.4-45.8)*	36.8 (30.2-43.4)*	43.9 (37.5-50.2)	45.6 (40.0-51.2)
	14-16	46.1 (41.7-50.6)	53.0 (48.0-57.9)	36.7 (30.1-43.3)	26.8 (20.7-32.8)*	31.2 (25.3-37.2)*	37.7 (32.2-43.2)
Language Use							
English + Other Language(s) (%)	11-13	5.5 (3.5-7.5)	23.4 (19.2-27.6)*	65.2 (58.7-71.8)*	72.2 (66.1-78.4)*	89.5 (85.5-93.4)*	94.8 (92.2-97.3)*
	14-16	6.1 (4.0-8.3)	23.7 (19.4-27.9)*	71.5 (65.3-77.7)*	80.4 (75.0-85.8)*	93.7 (90.5-96.8)*	95.7 (93.5-98.0)*
Attendance at place of worship							
≥ 1 per week (%)	11-13	5.9 (3.8-8.0)	37.3 (32.4-42.1)*	74.4 (68.4-80.4)*	58.4 (51.6-65.1)*	50.2 (43.8-56.6)*	76.4 (71.6-81.1)*
	14-16	5.1 (3.1-7.1)	28.3 (23.8-32.8)*	74.4 (68.4-80.4)*	65.1 (58.6-71.6)*	43.5 (37.1-49.8)*	75.1 (70.2-80.0)*
< 1 per week (%)	11-13	26.9 (23.0-30.9)	39.6 (34.7-44.5)*	15.9 (10.9-21.0)*	24.9 (19.0-30.8)	35.9 (29.7-42.0)	16.1 (11.9-20.2)*
	14-16	23.3 (19.5-27.0)	48.8 (43.9-53.8)*	19.8 (14.3-25.3)	25.8 (19.9-31.8)	48.9 (42.5-55.4)*	21.6 (17.0-26.3)
Never (%)	11-13	67.1 (63.0-71.3)	23.1 (18.9-27.3)*	9.7 (5.6-13.7)*	16.7 (11.6-21.9)*	13.9 (9.5-18.4)*	7.5 (4.6-10.5)*
	14-16	71.6 (67.6-75.6)	22.9 (18.7-27.1)*	5.8 (2.6-9.0)*	9.1 (5.2-13.0)*	7.6 (4.2-11.0)*	3.3 (1.3-5.3)*

* Significantly different from White UK, ^ Value at 14-16yrs significantly different to 11-13yrs within ethnic group (significance determined by non-overlapping confidence intervals)

Table 6.13 Girls: Measures of Acculturation by age and ethnicity

	Age (yrs)	White UK	Black Caribbean	Nigerian/ Ghanaian	Other African	Indian	Pakistani/ Bangladeshi
N		380	389	297	177	181	140
Generational Status							
Born Abroad / <10yrs in UK (%)	11-13	1.3 (0.2-2.5)	23.9 (19.7-28.2)*	17.2 (12.9-21.5)*	56.5 (49.1-63.9)*	23.8 (17.5-30.0)*	15.0 (9.0-21.0)*
Friends of same ethnicity as self							
Most or all (%)	11-13	27.4 (22.9-31.9)	32.6 (28.0-37.3)	27.3 (22.2-32.4)	14.7 (9.4-20.0)*	19.9 (14.0-25.8)	14.3 (8.4-20.2)*
	14-16	25.5 (21.1-29.9)	36.0 (31.2-40.8)*	33.7 (28.3-39.1)	18.6 (12.9-24.4)	22.1 (16.0-28.2)	17.9 (11.4-24.3)
Quite a lot (%)	11-13	33.7 (28.9-38.5)	37.8 (32.9-42.6)	35.0 (29.6-40.5)	31.1 (24.2-38.0)	28.2 (21.6-34.8)	32.1 (24.3-40.0)
	14-16	39.7 (34.8-44.7)	36.2 (31.4-41.0)	37.0 (31.5-42.6)	33.3 (26.3-40.3)	40.3 (33.1-47.5)	45.7 (37.4-54.1)
Some or none (%)	11-13	38.9 (34.0-43.9)	29.6 (25.0-34.1)	37.7 (32.2-43.3)	54.2 (46.8-61.6)*	51.9 (44.6-59.3)*	53.6 (45.2-61.9)*
	14-16	34.7 (29.9-39.5)	27.8 (23.3-32.2)	29.3 (24.1-34.5)	48.0 (40.6-55.5)*	37.6 (30.4-44.7)	36.4 (28.4-44.5)^
Friends of different ethnicity to self							
Most or all (%)	11-13	10.3 (7.2-13.3)	4.6 (2.5-6.7)*	7.7 (4.7-10.8)	22.0 (15.9-28.2)*	13.3 (8.3-18.2)	14.3 (8.4-20.2)
	14-16	13.4 (10.0-16.9)	9.3 (6.4-12.1)	12.5 (8.7-16.2)	18.1 (12.4-23.8)	22.7 (16.5-28.8)	15.0 (9.0-21.0)
Quite a lot (%)	11-13	41.3 (36.3-46.3)	39.1 (34.2-43.9)	48.1 (42.4-53.9)	41.2 (33.9-48.6)	42.0 (34.7-49.2)	40.7 (32.5-49.0)
	14-16	41.3 (36.3-46.3)	33.9 (29.2-38.7)	43.4 (37.8-49.1)	41.8 (34.5-49.1)	46.4 (39.1-53.7)	46.4 (38.1-54.8)
Some or none (%)	11-13	48.4 (43.4-53.5)	56.3 (51.3-61.2)	44.1 (38.4-49.8)	36.7 (29.6-43.9)	44.8 (37.4-52.1)	45.0 (36.7-53.3)
	14-16	45.3 (40.2-50.3)	56.8 (51.9-61.8)*	44.1 (38.4-49.8)	40.1 (32.8-47.4)	30.9 (24.1-37.7)*	38.6 (30.4-46.7)
Language Use							
English + Other Language(s) (%)	11-13	4.2 (2.2-6.2)	27.8 (23.3-32.2)*	75.1 (70.1-80.0)*	75.7 (69.3-82.1)*	84.5 (79.2-89.8)*	97.9 (95.4-1.00)*
	14-16	6.6 (4.1-9.1)	36.0 (31.2-40.8)*	83.5 (79.3-87.7)*	86.4 (81.3-91.5)*	93.4 (89.7-97.0)*	95.0 (91.3-98.7)*
Attendance at place of worship							
≥ 1 per week (%)	11-13	8.9 (6.1-11.8)	48.6 (43.6-53.6)*	86.2 (82.2-90.1)*	60.5 (53.2-67.7)*	47.0 (39.6-54.3)*	52.1 (43.8-60.5)*
	14-16	7.4 (4.7-10.0)	38.0 (33.2-42.9)*	78.5 (73.7-83.2)*	52.5 (45.1-60.0)*	30.9 (24.1-37.7)*^	22.1 (15.2-29.1)*^
< 1 per week (%)	11-13	34.7 (29.9-39.5)	37.0 (32.2-41.8)	12.1 (8.4-15.9)*	25.4 (18.9-31.9)	44.8 (37.4-52.1)	20.7 (13.9-27.5)*
	14-16	28.2 (23.6-32.7)	46.3 (41.3-51.2)*	18.5 (14.1-23.0)*	39.5 (32.3-46.8)	58.0 (50.8-65.3)*	42.1 (33.9-50.4)*
Never (%)	11-13	56.3 (51.3-61.3)	14.4 (10.9-17.9)*	1.7 (0.2-3.2)*	14.1 (8.9-19.3)*	8.3 (4.2-12.3)*	27.1 (19.7-34.6)*
	14-16	64.5 (59.6-69.3)	15.7 (12.1-19.3)*	3.0 (1.1-5.0)*	7.9 (3.9-11.9)*	11.0 (6.4-15.7)*	35.7 (27.7-43.7)*

* Significantly different from White UK, ^ Value at 14-16yrs significantly different to 11-13yrs within ethnic group (significance determined by non-overlapping confidence intervals)

6.1.5 Relationship between socio-economic status (SES) and pupils' behaviours, parental lifestyles, and acculturation

A series of chi-squared tests, and logistic regressions where outcomes were binary, were conducted to determine if the individual and family characteristics were associated with SES. For this analysis, SES was measured by the standard of living quartiles. Associations were examined both overall and within ethnic group. Due to small numbers once analyses were stratified by ethnicity the focus was on patterns of association and not statistical significance.

6.1.5.1 SES and Pupil behaviours

Two measures of physical activity were considered; number of physical activity sessions and number of different activities (quartiles of both variables were used). There was no relationship between number of sessions and SES. The relationship between number of activities and SES was significant for the boys ($p=0.029$); the most deprived boys were more likely to be in Q4 (lowest number of activities) than the least disadvantaged boys. Within each of the ethnic groups a similar pattern was observed except for the Black Caribbean and Indian boys. For the girls the association between number of activities and SES was not statistically significant but the pattern was similar to the boys both overall and in each group, except for the Other Africans.

Fruit and vegetable consumption was associated with SES for both boys and girls ($p<0.001$ for both). Higher proportions of the least deprived pupils ate ≥5 portions compared to the most deprived pupils. Similarly the most deprived pupils were more likely to eat <1 portion than the least deprived pupils. A similar pattern was observed within each of the ethnic groups with the exception of the Other African girls (for whom the most deprived reported eating more fruit and vegetables than the least deprived).

The least deprived pupils were more likely to eat breakfast everyday than the most deprived pupils. Within ethnic group this pattern was only observed for the Other African boys, and the White UK and Nigerian/Ghanaian girls. For the Indian and Pakistani/Bangladeshi girls, the most deprived were actually the most likely to eat breakfast everyday.

Overall the least deprived girls were more likely to have tried smoking than the most deprived and the pattern was similar within each ethnic group, although statistically significant only for the White UK girls. The association was also significant for the White UK boys.

6.1.5.2 SES and Parental Lifestyle

Overall, the most disadvantaged boys were the most likely to report having an overweight mother, however this pattern was not observed for the girls. Within ethnic group, there was a tendency for maternal obesity to be associated with higher deprivation for the Black Caribbean, Nigerian/Ghanaian, Indian and Pakistani/Bangladeshi boys but this was not observed for the girls, for whom there appeared to be no association between SES and the reporting of maternal overweight. An exception was the Pakistani/Bangladeshi girls for whom there was a significant association ($p=0.040$), however it was in the opposite direction; the less deprived reported more maternal overweight then the more deprived.

Overall, and within each ethnic group, there was no association between SES and having an overweight father for the boys. For the girls the overall association was significant ($p=0.002$), the least deprived were the most likely to say that their dad was not overweight. Within ethnic group the pattern was generally similar, an exception being the Indian girls (the least deprived were the most likely to have an overweight father).

For both the White UK and Black Caribbean boys and girls, maternal smoking was associated with deprivation (the numbers of smoking mothers were too small in the other ethnic groups to determine any patterns). Overall, fathers' smoking was also associated with deprivation for both boys and girls. This pattern was strongest for the White UK and Black Caribbean groups; there was no association between paternal smoking and SES for the Other African, Indian or Pakistani/Bangladeshi boys or the Nigerian/Ghanaian, Indian, or Pakistani/Bangladeshi girls.

6.1.5.3 SES and Acculturation

Being born abroad was associated with deprivation for both boys and girls ($p<0.001$ for both). Within ethnic group this pattern held, with the exception of the Pakistani/Bangladeshi boys. In most ethnic groups there was a trend across deprivation categories in the proportion who were born abroad (being lowest for the least deprived group and highest for the most deprived group).

There was no association between ethnicity of friends and SES. Within ethnic group there was no association between language use and SES. Religious attendance was significantly associated with SES for Other African and Indian and Pakistani/Bangladeshi girls; in all cases the most deprived were the most likely to attend a place of worship ≥1 per week. The association was also significant for the Black Caribbean girls but the association was in the opposite direction; the more deprived were the most likely to never go to church. For the boys, the association was only significant for the Indians; as with the girls the most deprived were the most likely to attend ≥1 per week, but they were also the most likely to never attend (they had low proportions attending <1 per week). Regular attendance (≥1 per week) was lowest in the most deprived group for the Black Caribbean and Nigerian/Ghanaian boys. There was no pattern between SES and religious attendance for the Other African and Pakistani/Bangladeshi boys (which is different to what was observed for the girls).

6.1.6 Key Points - Individual and Family characteristics

- Girls participated in less physical activity than boys, and both genders reported less physical activity at 14-16yrs than at 11-13yrs. The Black Caribbeans, Nigerian/Ghanaians, and Indian boys reported the most sedentary behaviour.

- Girls were more likely to skip breakfast than boys. Only a third of pupils ate the recommended ≥5 portions of fruit and vegetables per day. The White UK and Indian pupils reported the most favourable dietary behaviours.

- The White UK pupils were the most likely to smoke at 14-16yrs, with the proportion being almost twice as high in White UK girls compared to White UK boys (31% versus 16%). In contrast, <2% of the Pakistani/Bangladeshi girls were smokers.

- The Pakistani/Bangladeshi girls were the most likely to report living with an overweight mother and the Black Caribbean boys least likely. The Black Caribbeans, Nigerian/Ghanaians and Other Africans were least likely to report living with an overweight father. Parental smoking was most prevalent in the homes of the White UK pupils. The mothers of the Black Caribbeans, and the fathers of the Pakistani/Bangladeshis, also had relatively high smoking rates.

- Across the range of family SES measures, the White UK and Indian groups were least deprived and the Other Africans and Pakistani/Bangladeshis tended to be the most deprived. There was agreement between the pupil-reported family-level deprivation measures and the objectively measured neighbourhood and school deprivation measures; pupils from more deprived families were the most likely to live in a deprived area and to attend a deprived school. However the strength of these associations differed by ethnic group.

- Higher family SES tended to be associated with higher fruit and vegetable consumption, trying smoking for the White UK pupils, and less parental smoking for the White UK and Black Caribbean pupils.

- Many of the ethnic minority pupils reported behaviours associated with their own cultural background (such as language use and regular attendance at a place of worship). In addition, the majority of pupils had friends of both their own and other ethnicities.

6.2 The association between individual and family characteristics and body size

Each of the individual and family variables was added to the baseline model (that is, the model adjusting for age, height and pubertal status) individually. The modelling strategy was the same as that described previously; in summary, the significance of the association between each variable and BMI SDS and Waist SDS was determined, then the interaction between each variable and ethnicity was assessed. Where a significant interaction was found, models were then stratified by ethnicity. Finally, interactions with age were examined.

6.2.1 Pupil behaviours and body size

The associations between the pupil behaviour measures and body size are summarised in Table 6.14 and detailed in the following section.

Table 6.14 Individual behaviours and Body Size Summary

		Boys		Girls	
		BMI SDS	Waist SDS	BMI SDS	Waist SDS
Physical Activity					
No. of different activities	Q1 (lowest)	Ref	Ref	Ref	Ref^
	Q2	-0.02 (-0.08-0.04)	-0.05 (-0.13-0.04)	-0.01 (-0.06-0.05)	-0.02 (-0.11-0.08)
	Q3	0.06 (0.00-0.12)*	0.03 (-0.05-0.10)	0.03 (-0.03-0.08)	0.06 (-0.03-0.14)
	Q4	0.10 (0.02-0.17)*	0.04 (-0.06-0.14)	0.11 (0.04-0.18)*	0.14 (0.04-0.25)*
No. of activity sessions	Q1 (lowest)	Ref^	Ref	Ref	Ref
	Q2	-0.04 (-0.10-0.02)	-0.06 (-0.14-0.02)	0.03 (-0.03-0.09)	-0.00 (-0.10-0.09)
	Q3	-0.04 (-0.10-0.03)	-0.09 (-0.17--0.00)*	0.05 (-0.01-0.11)	0.08 (-0.02-0.17)
	Q4	-0.00 (-0.07-0.07)	-0.06 (-0.15-0.04)	0.07 (0.00-0.14)*	0.13 (0.03-0.23)*
No. breathless sessions	Q1 (lowest)	Ref	Ref	Ref	Ref
	Q2	0.06 (-0.11-0.23)	0.05 (-0.10-0.20)	0.01 (-0.14-0.17)	0.06 (-0.10-0.23)
	Q3	-0.05 (-0.21-0.10)	-0.00 (-0.14-0.13)	-0.05 (-0.22-0.11)	-0.10 (-0.27-0.07)
	Q4	0.08 (-0.08-0.24)	0.09 (-0.05-0.24)	0.07 (-0.10-0.24)	0.07 (-0.11-0.24)
Total active time	Q1 (least time)	Ref	Ref	Ref	Ref
	Q2	0.02 (-0.14-0.19)	0.03 (-0.11-0.18)	-0.01 (-0.17-0.16)	-0.00 (-0.18-0.17)
	Q3	0.03 (-0.14-0.19)	0.00 (-0.15-0.15)	0.06 (-0.10-0.22)	-0.02 (-0.19-0.15)
	Q4	0.06 (-0.11-0.22)	0.02 (-0.13-0.16)	0.10 (-0.06-0.27)	0.09 (-0.08-0.26)
Total breathless time	Q1 (least time)	Ref	Ref	Ref	Ref
	Q2	-0.02 (-0.19-0.14)	-0.03 (-0.17-0.12)	-0.01 (-0.18-0.16)	0.03 (-0.15-0.20)
	Q3	-0.01 (0.18-0.16)	0.04 (-0.12-0.19)	-0.04 (-0.20-0.13)	-0.06 (-0.23-0.10)
	Q4	0.03 (-0.14-0.19)	-0.01 (-0.16-0.14)	0.07 (-0.09-0.23)	0.08 (-0.09-0.25)
Active transport	To and/or from school	Ref	Ref	Ref	Ref
	No active transport	0.00 (-0.12-0.12)	0.04 (-0.07-0.14)	-0.00 (-0.13-0.12)	-0.03 (-0.16-0.11)
Sedentary time	Q1 (least)	Ref	Ref	Ref^	Ref^
	Q2	0.01 (-0.15-0.17)	-0.01 (-0.15-0.13)	0.03 (-0.14-0.20)	0.10 (-0.08-0.28)
	Q3	-0.09 (-0.26-0.08)	-0.06 (-0.21-0.09)	0.11 (-0.05-0.27)	0.04 (-0.12-0.20)
	Q4	-0.06 (-0.22-0.10)	-0.08 (-0.23-0.06)	0.12 (-0.04-0.29)	0.12 (-0.05-0.29)
Diet					
Fruit and Vegetables	>=5 a day	Ref	Ref	Ref	Ref
	1-4 a day	0.04 (-0.02-0.09)	0.06 (-0.01-0.13)	-0.05 (-0.10-0.01)	-0.03 (-0.12-0.05)
	<1 a day	-0.01 (-0.08-0.05)	-0.02 (-0.11-0.06)	-0.08 (-0.14--0.01)*	-0.08 (-0.17-0.02)
Eating breakfast	Everyday	Ref	Ref	Ref^	Ref
	Not everyday	0.34 (0.22-0.47)*	0.25 (0.14-0.37)*	0.35 (0.23-0.47)*	0.26 (0.14-0.38)*
Smoking	Never Tried	Ref^	Ref	Ref	Ref
	Tried Once	0.04 (-0.02-0.10)	0.06 (-0.02-0.14)	-0.00 (-0.06-0.06)	-0.06 (-0.16-0.03)
	Given Up	0.04 (-0.09-0.17)	-0.01 (-0.18-0.17)	-0.08 (-0.20-0.04)	-0.09 (-0.28-0.09)
	Smoker	0.01 (-0.10-0.13)	0.02 (-0.13-0.17)	-0.04 (-0.14-0.06)	0.01 (-0.14-0.16)
Sleep	<=6hrs	Ref	Ref	Ref	Ref
	7hrs	-0.06 (-0.30-0.17)	-0.12 (-0.33-0.09)	0.07 (-0.15-0.30)	0.02 (-0.21-0.25)
	8hrs	-0.01 (-0.22-0.20)	-0.03 (-0.22-0.16)	-0.06 (-0.27-0.14)	-0.05 (-0.27-0.16)
	9hrs	-0.20 (-0.42-0.01)	-0.17 (-0.37-0.02)	-0.08 (-0.29-0.14)	-0.06 (-0.28-0.16)
	>=10hrs	-0.16 (-0.39-0.07)	-0.16 (-0.36-0.05)	-0.14 (-0.38-0.10)	-0.03 (-0.27-0.21)

*Significantly different to reference category ($p<0.05$)

^ Significant interaction between variable and ethnicity. P-values for the interaction terms are given below, full details in text.

Boys BMI SDS: Number of activity sessions p=0.037; smoking p=0.0019

Girls BMI SDS: Eating breakfast p=0.038; Sedentary time p=0.004

Girls Waist SDS: Number of different activities p=0.038; Sedentary time p=0.001

6.2.1.1 Physical activity and body size

Reporting a greater number of activities was associated with a significantly higher BMI SDS for both boys and girls. For boys, compared to those reporting 0-2 activities (Q1), those who did 4-5 activities or 6+ activities had higher BMI SD scores. For girls, compared to those who did 0-1 activity (Q1), those reporting 5+ activities (Q4) had higher BMI SD scores. The interaction with ethnicity was significant for Waist SDS for girls. Stratified analysis showed that this variable was significant only for Nigerian/Ghanaian and Other African girls. For the Nigerian/Ghanaians, those who did 5+ activities had higher Waist SD scores (0.37, 0.15 to 0.59, p=0.001) than those who did 0-1 activity. For the Other Africans those in Q2 (0.29, -0.02 to 0.59, p=0.063), Q3 (0.32, 0.05 to 0.59, p=0.018) and Q4 (0.38, 0.06 to 0.70, p=0.018) had higher Waist SD scores than those in Q1, with a linear trend across the categories.

Number of activity sessions was associated with BMI SDS and Waist SDS for girls. Those reporting 12+ sessions (Q4) had higher BMI and Waist SD scores than those who did 02-sessions (Q1). For boys, there was a significant interaction with ethnicity for BMI SDS. This variable was only significant for the Other African boys; those in Q2 (-0.30, -0.49 to -0.12, p=0.001) and Q3 (-0.28, -0.47 to -0.09, p=0.004) had significantly lower BMI SD scores than those in Q1, however those in Q4 did not (-0.15, -0.36 to 0.05).

The physical activity variables which were only measured at 14-16yrs, total breathless time and number of breathless activity sessions, were not significantly associated with BMI SDS or Waist SDS for either boys or girls and no interactions with ethnicity were significant. Active transport and number of hours of sleep were also not significantly associated with body size, and again no interactions with ethnicity were significant. However for both boys and girls there was a suggestion of a slight trend across the sleep categories; boys and girls sleeping for longer tended to have lower BMI and Waist SD scores.

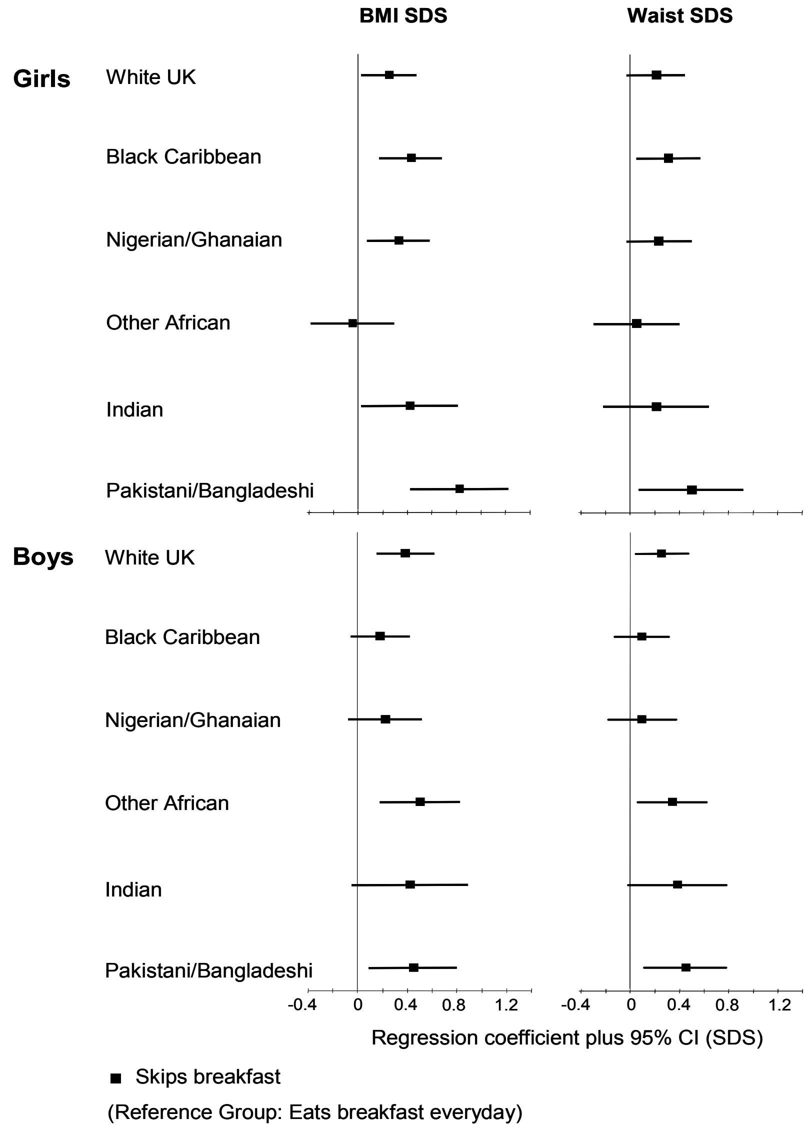
Sedentary time, again only measured at 14-16yrs, was not significant for boys or girls overall but there was a significant interaction with ethnicity for girls for both BMI SDS (p=0.0040) and Waist SDS (p=0.001). For both outcomes, sedentary time was significant only for the White UK girls; compared to those in Q1 (0-4 sedentary units), those in Q3 (6.5-8 units) had significantly higher BMI SD scores (0.52, 0.22 to 0.81, p=0.001), as did those in Q4 (>=8.5 units) (0.50, 0.19 to 0.81, p=0.001). For Waist SDS, those in Q3 had scores 0.39 (0.08-0.70) higher (p=0.014), and those in Q4 0.57 (0.24-0.91) higher (p=0.001). Therefore self-reported sedentary behaviour was consistently associated with body size for White UK girls. However this was not seen for the other groups.

6.2.1.2 Diet and body size

Fruit and vegetable consumption was significantly associated with BMI SDS for girls. Those reporting <1 portion of fruit and vegetables per day had significantly lower BMI SD scores that those eating 5 or more portions. A similar pattern was observed for Waist SDS but differences did not reach statistical significance. There were no significant interactions with ethnicity. Fruit and vegetable consumption was not significantly associated with BMI SDS or Waist SDS for boys.

For both boys and girls, skipping breakfast at 11-13yrs was significantly associated with having higher BMI SD and Waist SD scores. For both boys and girls the effect sizes were slightly lower for Waist SDS compared to BMI SDS. Compared to the effect sizes observed for other variables, those observed here for skipping breakfast are large. There was a significant interaction between breakfast frequency and BMI SDS for the girls; in stratified analysis skipping breakfast was associated with a significantly higher BMI SDS for all groups except the Other Africans. Although interactions with ethnicity were not significant for either outcome for the boys, or for Waist SDS for the girls, models were re-run stratified by ethnicity to aid comparison with the girls BMI SDS results (Figure 6.5). Within sex, the patterns observed for BMI SDS and Waist SDS were similar. Skipping breakfast was not associated with body size for Other African girls, but it was for Other African boys. The largest effects were observed for the Pakistani/Bangladeshi girls (BMI SDS 0.82, 0.41 to1.22; Waist SDS 0.50, 0.07 to 0.92).

Figure 6.5 Association between skipping breakfast and body size by gender and ethnic group



6.2.1.3 Smoking and body size

Smoking was not associated with BMI SDS or Waist SDS for either boys or girls overall, however there was a significant interaction between smoking and ethnicity in their association with BMI SDS for boys. For Nigerian/Ghanaian and Other African boys, smokers had significantly higher BMI SD scores than those who had never tried smoking (reference group). For Other African boys, those who were smokers had BMI SD scores 0.72 (0.19-1.24) higher, and the Nigerian/Ghanaians 0.85 (0.25-1.45) higher, than those who had never tried. However it is important to stress the very small number of smokers in these groups and therefore the significance of this result should not be overstated.

6.2.1.4 Variance in body size explained by pupil behaviours

The impact on variance of each of the significant pupil behaviour variables was examined (Table 6.15). Where an interaction term was significant, the figures in the table are from the model including the interaction term. Breakfast frequency explained over a third of the boys' between school variance in BMI SDS but actually slightly increased the girls' BMI SDS school-level variance and the Waist SDS school-level variance of both boys and girls. Adjusting for sedentary activity reduced between school variance by 6.4% for boys, and 10.0% for girls but had little impact on Waist SDS variance. Smoking status increased between school variance in BMI SDS for the boys by over 10% but made little impact on the girls' school variance or on Waist SDS variance for either sex.

At the individual level, breakfast frequency explained a small proportion of between individual BMI SDS variance (boys 1.4%; girls 2.7%). Sedentary behaviour explained 1.2% of between girls variability. The impact of the other factors was very small, explaining only a fraction of a percent of the variance.

Table 6.15: Proportion of BMI SDS and Waist SDS variance explained by selected pupil behaviour factors

	Variance (Baseline)	% variance explained by each model Fruit and Veg	Breakfast	No. different activities	Sedentary Activity	Smoking
BMI SDS						
Boys						
School	0.006	0.29	36.05	-1.30	6.35	-11.53
Individual	1.517	0.07	1.38	0.20	-0.09	0.01
Measurement	0.239	0.01	0.11	0.14	0.00	1.00
Total	1.762	0.06	1.32	0.19	-0.06	0.11
Girls						
School	0.015	-0.60	-1.78	-4.87	9.98	0.08
Individual	1.317	0.19	2.67	0.21	1.21	-0.18
Measurement	0.186	0.06	0.01	0.43	-0.01	0.09
Total	1.517	0.17	2.30	0.18	1.14	-0.15
Waist SDS						
Boys						
School	0.022	-0.06	-0.39	-0.86	1.99	-0.07
Individual	1.055	0.13	1.14	0.03	-0.04	0.03
Measurement	0.479	0.07	0.09	-0.02	-0.01	-0.06
Total	1.556	0.11	0.80	0.00	0.00	0.00
Girls						
School	0.036	-0.48	-1.10	-3.38	-1.72	0.34
Individual	1.245	0.24	1.24	0.08	1.45	0.04
Measurement	0.504	-0.09	-0.01	0.27	-0.03	-0.04
Total	1.785	0.13	0.84	0.06	0.97	0.02

6.2.2 Parental behaviours and body size

The associations between the pupil behaviour measures and body size are summarised in Table 6.16 and detailed in the following section.

Table 6.16 Parental lifestyle and body size summary

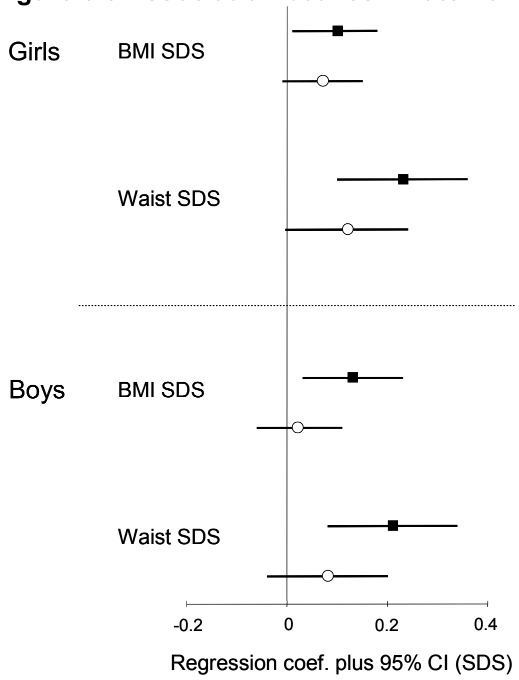
		Boys		Girls	
		BMI SDS	Waist SDS	BMI SDS	Waist SDS
Mother's smoking status	Non-smoker	Ref	Ref	Ref	Ref
	Smoker	0.08 (-0.03-0.19)	0.11 (-0.02-0.23)	0.10 (-0.01-0.20)	0.26 (0.11-0.40)*
	Not resident	0.08 (-0.06-0.22)	0.08 (-0.09-0.26)	0.08 (-0.06-0.21)	0.19 (-0.00-0.39)
Father's smoking status	Non-smoker	Ref	Ref	Ref	Ref
	Smoker	0.02 (-0.07-0.11)	0.06 (-0.05-0.16)	-0.01 (-0.10-0.08)	0.01 (-0.11-0.14)
	Not resident	0.06 (-0.03-0.14)	0.06 (-0.04-0.16)	-0.01 (-0.10-0.07)	0.03 (-0.08-0.14)
Mother's overweight status	No	Ref	Ref	Ref	Ref
	Yes	0.13 (0.03-0.23)*	0.21 (0.08-0.34)*	0.10 (0.01-0.18)*	0.23 (0.10-0.36)*
	Don't Know	0.02 (-0.06-0.11)	0.08 (-0.04-0.20)	0.07 (-0.01-0.15)	0.12 (-0.00-0.24)
	Not resident	0.08 (-0.06-0.22)	0.09 (-0.08-0.26)	0.07 (-0.06-0.21)	0.18 (-0.02-0.38)
Father's overweight status	No	Ref	Ref	Ref	Ref
	Yes	0.01 (-0.11-0.12)	0.13 (-0.02-0.27)	0.07 (-0.04-0.18)	0.11 (-0.06-0.28)
	Don't Know	0.01 (-0.10-0.12)	0.09 (-0.06-0.24)	0.02 (-0.09-0.12)	0.06 (-0.10-0.21)
	Not resident	0.05 (-0.03-0.13)	0.05 (-0.04-0.15)	0.00 (-0.07-0.08)	0.04 (-0.07-0.15)

*Significantly different to reference category ($p<0.05$)

6.2.2.1 Parental overweight and body size

Having an overweight mother was significantly associated with an increased BMI SDS and Waist SDS for both boys and girls (Figure 6.6). For both boys and girls having an overweight mother had a slightly larger effect on Waist SDS than on BMI SDS. There was also a tendency for those who did not know if their mother was overweight to have higher BMIs and larger Waists although these associations were not statistically significant. There was no significant difference in body size between those whose mother was not resident and the reference category (not overweight) for either boys or girls. There was also no significant interaction between maternal overweight and ethnicity for either sex. In contrast to what was observed for maternal overweight, there was no significant association for fathers' overweight status, and no interactions with ethnicity.

Figure 6.6 Association between maternal overweight and body size



■ Mother overweight
○ Don't know if mother overweight
(Reference Group: Mother not overweight)

6.2.2.2 Parental smoking and body size

Mother and fathers' smoking status was not significantly associated with BMI SDS. Mother's smoking status was associated with Waist SDS for girls; compared to those whose mothers did not smoke, girls whose mother did smoke had a higher Waist SDS. Boys' Waist SDS was not associated with their mother's smoking status. Interactions between mothers' or fathers' smoking status and ethnicity were not significant for either BMI SDS or Waist SDS for either sex.

6.2.2.3 Variance in body size explained by parental behaviours

Although maternal overweight was a significant correlate of both body size measures for boys and girls, it only explained a small percentage of the variance; 2% of the variance in Waist SDS and 1% of the variance in BMI SDS at the individual level for girls, with proportions being slightly lower for the boys (Table 6.17). The proportion of variance explained by parental smoking, and fathers' overweight was small.

Table 6.17: Proportion of BMI SDS variance explained by selected pupil behaviour factors

	Variance (Baseline)	% variance explained by each model			
		Overweight Mum	Overweight Dad	Smoking Mum	Smoking Dad
BMI SDS					
Boys					
School	0.006	0.57	3.11	4.87	5.36
Individual	1.517	0.55	0.08	0.23	-0.02
Measurement	0.239	-0.28	-0.15	-0.15	0.00
Total	1.762	0.44	0.06	0.19	0.00
Girls					
School	0.015	-6.76	-0.11	-0.31	-0.40
Individual	1.317	0.98	0.15	0.37	-0.06
Measurement	0.186	-0.56	-0.21	-0.22	-0.06
Total	1.517	0.72	0.10	0.29	-0.06
Waist SDS					
Boys					
School	0.022	-1.54	-1.10	-1.10	0.76
Individual	1.055	1.01	0.32	0.37	-0.23
Measurement	0.479	-0.29	-0.14	-0.19	0.14
Total	1.556	0.58	0.16	0.18	-0.10
Girls					
School	0.036	-7.96	-0.07	2.01	0.39
Individual	1.245	2.08	0.57	1.19	0.06
Measurement	0.504	-0.71	-0.45	-0.19	-0.14
Total	1.785	1.09	0.27	0.81	0.01

6.2.3 Socio-economic circumstances and body size

The associations between the measures of family socioeconomic circumstances and body size are summarised in Table 6.18 and detailed in the following section.

Table 6.18 SES and body size summary

		Boys BMI SDS	Boys Waist SDS	Girls BMI SDS	Girls Waist SDS
Standard of living score	Q1 (most affluent)	Ref	Ref	Ref	Ref
	Q2	-0.00 (-0.07-0.07)	-0.00 (-0.09-0.09)	-0.01 (-0.08-0.06)	-0.01 (-0.12-0.10)
	Q3	0.00 (-0.07-0.07)	0.01 (-0.07-0.10)	0.00 (-0.07-0.07)	-0.00 (-0.10-0.10)
	Q4	-0.09 (-0.18--0.00)*	-0.08 (0.19-0.03)	-0.03 (-0.12-0.06)	-0.01 (-0.14-0.12)
Overcrowding	No	Ref	Ref	Ref	Ref
	Yes	-0.01 (-0.08-0.07)	0.01 (-0.08-0.11)	-0.07 (-0.15--0.00)*	-0.09 (-0.20-0.02)
Family Type	Two parent	Ref	Ref	Ref	Ref
	One parent	0.06 (-0.02-0.14)	0.08 (-0.02-0.17)	-0.01 (-0.09-0.06)	0.03 (-0.07-0.14)
	Other	0.06 (-0.13-0.25)	-0.06 (-0.30-0.18)	0.09 (-0.10-0.27)	0.16 (-0.11-0.42)
Parental employment	>=1 employed	Ref	Ref	Ref	Ref
	None employed	0.00 (-0.07-0.08)	0.02 (-0.08-0.11)	0.03 (-0.04-0.11)	0.04 (-0.07-0.14)
	No resident parent figure	0.04 (-0.16-0.23)	-0.08 (-0.32-0.16)	0.11 (-0.07-0.29)	0.15 (-0.12-0.41)
Family type & employment	2 parent working	Ref	Ref	Ref	Ref
	1 parent working	0.05 (-0.04-0.14)	0.09 (-0.02-0.20)	-0.03 (-0.11-0.05)	0.02 (-0.10-0.14)
	2 parent not working	-0.05 (-0.16-0.06)	0.01 (-0.13-0.15)	0.02 (-0.09-0.14)	0.01 (-0.17-0.18)
	1 parent not working	0.07 (-0.04-0.17)	0.07 (-0.06-0.19)	0.02 (-0.07-0.12)	0.06 (-0.08-0.20)
	Other	0.06 (-0.14-0.25)	-0.06 (-0.30-0.18)	0.10 (-0.09-0.28)	0.16 (-0.11-0.43)
Car ownership	Yes	Ref^	Ref	Ref	Ref
	No	-0.01 (-0.10-0.07)	-0.05 (-0.15-0.05)	0.01 (-0.07-0.09)	-0.02 (-0.13-0.09)
Private garden	Yes	Ref	Ref	Ref^	Ref^
	No	-0.01 (-0.09-0.07)	-0.08 (-0.18-0.01)	0.02 (-0.06-0.09)	-0.04 (-0.15-0.06)

*Significantly different to reference category ($p<0.05$)

^ Significant interaction between variable and ethnicity. P-values for the interaction terms are given below, full details in text.

Boys BMI SDS: Car ownership p=0.007

Girls BMI SDS: Private garden p=0.004; Girls Waist SDS: Private garden p=0.034

Each of the socio-economic variables was entered individually into the BMI SDS and Waist SDS baseline models. The only variable to be significantly associated with BMI SDS was overcrowding for girls; those who lived in overcrowded homes had lower BMI SD scores than those who did not. None of the socio-economic variables were found to be significantly associated with Waist SDS for either boys or girls. There were no significant interactions between these variables and ethnicity for BMI SDS or Waist SDS for either the boys or girls.

The SES variables explained little or none of the between school, individual or measurement variance (Table 6.19). For girls, the standard of living quartiles explained the most between school variance in BMI SDS (1.4%); for boys it was family type (5.14%). None of these variables explained more than a third of a percent of the between individual or between measurement variance. The proportion of variance explained by each of the variables was generally lower for Waist SDS than BMI SDS.

Table 6.19: Proportion of BMI SDS and Waist SDS variance explained by SES factors

	Variance (baseline)	% variance explained by each model			
		Standard of living quartiles	Family Type	Parental employment	Crowding
BMI SDS					
Boys					
School	0.006	-5.63	5.14	0.05	0.27
Individual	1.517	-0.13	0.11	0.01	0.00
Measurement	0.239	0.33	-0.08	-0.10	-0.05
Total	1.762	-0.09	0.10	-0.01	-0.01
Girls					
School	0.015	1.41	-0.91	-2.19	0.75
Individual	1.317	-0.01	0.05	0.10	0.02
Measurement	0.186	-0.13	-0.09	-0.08	0.16
Total	1.517	-0.01	0.03	0.06	0.04
Waist SDS					
Boys					
School	0.022	0.84	1.19	0.08	-0.08
Individual	1.055	-0.33	0.06	-0.07	-0.01
Measurement	0.479	0.27	0.00	-0.01	-0.03
Total	1.556	-0.13	0.06	-0.05	-0.02
Girls	0.036	-0.15	-1.12	-1.76	-0.24
School	1.245	-0.05	0.22	0.27	-0.09
Individual	0.504	-0.12	-0.18	-0.21	0.14
Measurement	1.785	-0.08	0.08	0.10	-0.03
Total	0.022	0.84	1.19	0.08	-0.08

Car ownership and having a private garden at home were considered separately from the other standard of living items. Neither of these variables was significantly associated with BMI SDS for either boys or girls overall, however there were significant interactions with ethnicity. For boys, the interaction between car ownership and ethnicity was significant. Car ownership was significantly associated with BMI SDS only for Indian boys; those whose families did not own a car had BMI SD scores 0.55 (95% CI: 0.15 to 0.95) higher than those who did, however only small numbers of Indian boys lived in families without a car.

For girls, the interaction between ethnicity and having a private garden was significant for both BMI SDS and Waist SDS. For the Nigerian/Ghanaian girls, not having a garden was associated with having a lower BMI SDS (-0.18, -0.32 to -0.05) and a lower Waist SDS (-0.21, -0.39 to -0.02). However for Other Africans not having a garden was associated with having a significantly higher BMI SDS (0.21, 0.04 to 0.37) and Waist SDS (0.28, 0.01 to

0.55). Similarly, for the Black Caribbean girls those who did not have a garden had higher Waist SD scores than those who did (0.22, 0.03 to 0.41).

6.2.4 Acculturation and body size

The associations between the acculturation measures and body size are summarised in Table 6.20 and detailed in the following section.

Table 6.20 Acculturation and body size summary

		Boys		Girls	
		BMI SDS	Waist SDS	BMI SDS	Waist SDS
Religious attendance	>=1 time per week	Ref	Ref^	Ref	Ref
	< once per week	-0.05 (-0.12-0.02)	-0.08 (-0.16-0.01)	-0.01 (-0.07-0.05)	-0.10 (-0.19--0.00)
	Never	-0.01 (-0.09-0.08)	0.01 (-0.09-0.12)	-0.03 (-0.11-0.06)	-0.05 (-0.17-0.07)
Language Use	English Only	Ref	Ref	Ref	Ref
	Other language(s)	0.05 (-0.03-0.12)	0.05 (-0.05-0.15)	0.00 (-0.07-0.08)	0.02 (-0.09-0.12)
Generational Status	Born in UK	Ref	Ref	Ref	Ref
	Born Abroad	-0.07 (-0.23-0.09)	-0.06 (-0.20-0.08)	0.03 (-0.13-0.19)	0.03 (-0.14-0.20)
Friends of different ethnicity	Quite a lot	Ref	Ref^	Ref^	Ref
	Most	0.03 (-0.05-0.11)	0.01 (-0.09-0.12)	0.06 (-0.01-0.14)	0.09 (-0.02-0.21)
	Some or none	-0.04 (-0.09-0.01)	-0.04 (-0.10-0.03)	0.01 (-0.04-0.06)	-0.00 (-0.08-0.07)

^ Significant interaction between variable and ethnicity. P-values for the interaction terms are given below, full details in text.

Boys Waist SDS: Religious attendance p=0.014; Friends of different ethnicity p=0.013

Girls BMI SDS: Friends of different ethnicity p=0.042

There was no significant association with either body size measure, or interactions with ethnicity, for generational status or language use for either boys or girls. For girls, the association between religious attendance and Waist SDS was borderline significant (p=0.05); those who attended a place of worship less than weekly had lower SD scores than those who attended at least once a week. The difference with those who never attended was not significant, and the interaction with ethnicity was not significant.

For boys, there was a significant interaction between religious attendance and Waist SDS; in stratified analysis religious attendance was significant for White UK and Indian boys only. For White UK boys, compared to those who attended a place of worship at least once a week, those who attended less than weekly (-0.44, -0.73 to -0.15) or never (-0.38, -0.67 to -0.09) had significantly lower waist SD scores. For Indian boys, those who attended less than weekly also had significantly lower SD scores than those who attended at least once a week (-0.27, -0.51 to -0.02). There was no significant difference between those who never attended and those who attended at least once a week (however the number of measurements for ‘never’ was only 51 for the Indian boys).

Ethnicity of friends was not significantly related to body size in overall analysis, however there were significant interactions with ethnicity for BMI SDS for girls and Waist SDS for boys. The baseline group of the ‘friends of different ethnicity’ variable was ‘quite a lot’. For White UK girls, those who said most of their friends were of a different ethnic group had significantly higher BMI SD scores (0.22, 0.05 to 0.38) than the baseline group. For the Black Caribbeans, those who reported that some/none of their friends were of a different ethnic group had significantly lower BMI SDS (-0.11, -0.21 to -0.02). However for the Nigerian/Ghanaians those who reported some/none had a significantly higher BMI SDS, although the effect size was very small (0.099, 0.002 to 0.20).

For boys, Black Caribbeans who reported that most or all of their friends were a different ethnicity to themselves had significantly higher waist SD scores than those who reported that quite a lot were of a different ethnic group (0.33, 0.06 to 0.59). However there was no significant difference between those who reported that some or none of their friends were a different ethnic group and those who reported that quite a lot were. For Nigerian/Ghanaian boys, those who reported that some or none of their friends were a different ethnicity to themselves had significantly lower SD scores (-0.23, -0.40 to -0.05), but there was no significant difference for those who reported ‘most or all’. This variable was also significant for the Indian boys; those reporting most or all had significantly lower SD scores (-0.45, -0.76 to -0.13) than those saying quite a lot.

The inclusion of the acculturation measures had little impact on variance at any level of the models (Table 6.21).

Table 6.21: Proportion of BMI SDS and Waist SDS variance explained by acculturation factors

	Variance (baseline)	% variance explained by each model Generational status	Language Use	Religious Attendance	Ethnicity of friends
BMI SDS					
Boys					
School	0.006	1.67	-0.86	1.29	2.09
Individual	1.517	-0.04	0.00	0.21	-0.10
Measurement	0.239	0.02	0.03	-0.14	0.34
Total	1.762	-0.03	0.00	0.17	-0.04
Girls					
School	0.015	-5.01	-0.15	2.33	-0.75
Individual	1.317	-0.02	0.00	-0.02	0.10
Measurement	0.186	0.00	-0.05	-0.10	0.49
Total	1.517	-0.07	-0.01	0.00	0.14
Waist SDS					
Boys					
School	0.022	-0.30	0.75	-0.81	0.30
Individual	1.055	-0.05	-0.07	0.85	-0.32
Measurement	0.479	0.02	0.04	0.11	0.77
Total	1.556	-0.03	-0.03	0.60	0.02
Girls	0.036				
School	1.245	-2.75	-0.11	-0.15	-0.43
Individual	0.504	-0.02	-0.03	-0.05	-0.07
Measurement	1.785	0.00	-0.03	0.15	0.09
Total	0.022	-0.07	-0.03	0.01	-0.03

6.2.5 Interactions with age

Interactions between each of the individual and family variables and wave were assessed to determine if the relationships observed previously were the same at both 11-13yrs and 14-16yrs. Interactions found to be significant are summarised in Table 6.22 in the same format used in the school and neighbourhood chapters. Overall there were few consistent results for boys and girls. Significant differences by age which showed consistency across outcome measures within sex, or otherwise showed a clear pattern, are described in more detail.

Eating less than one portion of fruit and vegetables per day had a stronger negative association with both body size measures for girls at 14-16yrs than 11-13yrs. The opposite pattern was observed for BMI SDS for boys; for them the association was stronger (although not significant) at 11-13yrs than 14-16yrs.

Girls with an overweight mother had significantly higher BMI and Waist SD scores at both 11-13yrs and 14-16yrs, with the association being stronger at the older ages. Girls who did not know if their mother was overweight also had significantly higher SD scores at both ages, but the association was less strong at 14-16yrs compared to 11-13yrs. The association between having a non-resident mother and body size was larger at 14-16yrs than 11-13yrs, and reached statistical significance for Waist SDS.

Girls who lived in a non-working household had significantly higher Waist SD scores that those in working households at 14-16yrs; this relationship was not observed at 11-13yrs. Further examination of the combined family type/parental employment variable showed that this relationship was driven by the girls in single parent non-working households (as opposed to those in two-parent non-working households).

For boys, those who attended places of worship less frequently (either less than once a week or never) tended to have lower BMI and Waist SD scores than those attending frequently, and this relationship was stronger at 14-16yrs than 11-13yrs.

Table 6.22 Interactions between individual and family measures and age

Empty cell if interaction was not significant (p>=0.05)

Filled cells contain p-value of interaction term (wave*variable)

First symbol indicates if effect of variable was positive (+) or negative (-) at W1

Second symbol indicates if effect of variable was + or – at W2.

* beside a direction of effect symbol (+ or -) indicates that the variable was significantly associated with the outcome at that wave.

If direction of effect the same at both waves, a third symbol is given which indicates whether the effect size is larger (▲) or smaller (▼) at W2 compared to W1.

Therefore if the effect at W1 was -0.3 (not significant) and at W2 -0.6 (significant) then the code would be - -* ▲.

		Boys BMI	Boys Waist	Girls BMI	Girls Waist
Individual behaviours					
Breathless time		P=0.0332			
	Q1 (Ref: least)				
	Q2	+ -			
	Q3	- - ▼			
	Q4	+ + ▲			
Sedentary time	Q1 (Ref: least)				P=0.0088
	Q2				+ + ▼
	Q3				+ + ▼
	Q4				+ + ▲
Active transport			P=0.020		
	Yes (Ref)				
	No		- +		
Fruit and Vegetables		P=0.0228		P=0.0364	P=0.0050
	>= 5 per day (Ref)				
	1-4 per day	+ -		+ -	- - ▼
	<1 per day	- - ▼		- -* ▲	- -* ▲
Parental behaviours					
Overweight mum				P=0.0454	
	No (Ref)				

	Yes			+* +* ▲	+* +* ▲
	Don't know			+* +* ▼	+* +* ▼
	Not resident			+ + ▲	+ +* ▲
SES					
Standard of living				P=0.0230	
	Q1 (Least disadvantaged: Ref)				
	Q2			+ + ▲	
	Q3			- - ▼	
	Q4			-* +	
Parental employment					P=0.0463
	>=1 employed (Ref)				
	None employed				- +*
	No resident parental figure				+ + ▲
Family type/Parental employment combined					P=0.0052
	2 parent, both working (Ref)				
	1 parent, working				+ -
	2 parent, no work				+ + ▼
	1 parent, no work				- +*
	No residential parental figure				+ + ▲
Car ownership	Yes (Ref)		P=0.028		
	No		- +		
Private garden					
	Yes (Ref)			P=0.005	
	No			- +	
Acculturation					
Religious attendance		P=0.0479	P=0.004		
	1+ per week (Ref)				
	<1 per week	-* -* ▲	-* -* ▲		
	Never	- - ▲	+ -*		
Language Use		P=0.005	P=0.005		
	English only (Ref)				
	Other languages	+ -	+ -		
Generational status		P=0.002	P=0.039	P=0.003	P=0.049
	Born / >10yrs in UK (Ref)				
	< 10yrs in UK	- +	- +	- +	+ + ▲
Friends of different ethnicity				P=0.0378	
	Quite a lot (Ref)				
	Most or all			- +	
	Some or none			- - ▼	

6.2.6 Key Points - Individual/family characteristics and body size

- Skipping breakfast and maternal overweight were the only two variables to show consistent results for both BMI SDS and Waist SDS for both boys and girls. Although other significant associations were found, results were often not consistent for both genders, or all ethnic groups, or both body size measures.

- Those who skipped breakfast had higher BMI and Waist SD scores than those who did not, with the effect being largest for the Pakistani/Bangladeshis. However the amount of total variance explained was small; around 1-2% for BMI SDS and <1% for Waist SDS.

- Living with an overweight mother was associated with having a higher BMI SDS and Waist SDS for both boys and girls. However as with skipping breakfast, the proportion of total variance explained was small; around 1% or less. The effect of having an overweight mother on body size was greater for girls at 14-16yrs than 11-13yrs.

- Pupils who reported a greater number of physical activities/activity sessions tended to have greater body size measures. Breathless time was not associated with body size. More sedentary behaviour was associated with an increase in body size for White UK girls but not any of the other gender/ethnic groups.

- Girls who reported eating few fruit or vegetables had smaller body sizes than those who ate more. This pattern was not observed for boys.

- Girls who lived with a mother who smoked had higher Waist SD scores than those who did not.

- There was little association between family-level SES and body size. There were some significant results for having a private garden but the direction of effect differed by ethnicity.

- White UK and Indian boys who attended a place of worship at least once a week had higher BMI SD scores than those who did not. The significant associations between ethnicity of friends and body size differed by ethnic group and gender.

6.3 Choice of variables for inclusion in final models

Both of the diet measures were selected; skipping breakfast was a strong correlate of both body size measures and for both sexes and fruit and vegetable intake was also selected as this was the only diet measure available at both waves and showed a significant association with BMI SDS for girls. Only two of the physical activity measures were measured at both waves; number of different activities and number of activity sessions. These were also the only two activity variables to show any association with body size. These variables were strongly correlated and so only number of activity sessions was chosen for inclusion in final models. The final pupil-behaviour variable to be included was student smoking status as this showed a significant association with BMI SDS for some of the boys' groups.

Mother's overweight status was a strong correlate of both body size measures for both sexes and was therefore selected. Mother's smoking status was also selected as it was related to Waist SDS for girls. Finally, father's overweight and smoking status were also chosen as they may have been related to the maternal characteristics.

Although there was little association between body size and measures of SES or cultural identity in the univariate analysis, it was decided to include these measures in the final models as both were strongly related to ethnicity. Furthermore generational status had been a significant correlate of overweight and obesity for Black Caribbean girls, and related to unfavourable dietary practices, at 11-13yrs in previous work (Harding et al., 2008b). The measures selected were; the standard of living items variable, the combined family type/parental employment variable, generational status, and friends of different ethnicity.

7 Ethnic differences in body size: the impact of individual, neighbourhood and school characteristics

The previous findings chapters have shown the association with body size of each of the school (Chapter 4), neighbourhood (Chapter 5), and individual and family (Chapter 6) variables when these were added individually to the baseline models (which adjusted for age, pubertal status, height and ethnicity). This final results chapter presents the findings from a series of systematically built models which determine whether there were neighbourhood and school effects on body size after individual and family covariates were adjusted for. Similarly, they also show whether individual and family effects on body size remained after adjustment for school and neighbourhood contexts. Finally, whether adjustment for individual, family, neighbourhood and school factors explained any of the ethnic differences in body size in adolescence is discussed.

In addition to examining BMI SDS and Waist SDS, the second part of this chapter considers overweight and obesity as outcomes. Many health policies focus on overweight and/or obesity rather than on the continuous measures of body size. Therefore, although a detailed examination of factors associated with ethnic differences in overweight and obesity was beyond the scope of this thesis, it was of interest to conduct some preliminary analyses to gain a broad perspective on whether patterns observed for BMI and waist were also evident for overweight and obesity.

The aims of this chapter were to determine if:

1. The patterns of association observed in the previous findings chapters remained in fully adjusted models.

2. Individual, family, neighbourhood or school characteristics could explain any of the ethnic differences in body size trends in adolescence.

3. The correlates which were significantly associated with BMI/Waist circumference were also significant for overweight/obesity.

4. Adjustment for individual, family, school and neighbourhood factors attenuated ethnic differences in overweight/obesity.

7.1 BMI SDS and Waist SDS

The model building steps are summarised in Table 7.1 and described in more detail in the Methods Chapter. Full results from all of the models are presented in the Appendix (Boys BMI SDS Table 8.3; Boys Waist SDS Table 8.4; Girls BMI SDS Table 8.5; Girls Waist SDS Table 8.6).

Table 7.1 Model Building Steps

Model	Variables included
Baseline	Age, height, pubertal status, ethnicity
Models 1-6 include individual, family, and neighbourhood variables	
1	Baseline + family SES (Standard of living items, family type/employment)
2	Model 1 + Acculturation (Generational status, friends of different ethnicity)
3	Model 2 + Individual behaviour (breakfast, fruit and vegetable, activity sessions, smoking)
4	Model 3 + Parental factors (Mum and Dad overweight and smoking)
5	Model 4 + Subjective neighbourhood (like area, safe day, safe night, good area)
6	Model 5 + Objective neighbourhood (IMD, own ethnic density)
Models 7-11 include school level variables	
7	Model 6 + school type (school sex and school religion)
8	Model 6 + school SES (academic performance and unauthorised absence)
9	Model 6 + school ethnic density
10	Model 6 + school SES + school ethnic density
11 (Girls only)	Model 6 + school type, school SES, and school ethnic density

7.1.1 Associations between body size and individual, family, neighbourhood and school measures in fully adjusted models

An overall finding was that the association between each of the covariates and the two body size measures tended to be very similar across the series of models, and similar to the results obtained in the univariate models presented in the previous chapters (Table 7.2 summarises which associations were significant in the univariate and multivariate models). Significant associations in the multivariate models will be described for each of the following sets of variables: individual behaviour, parental behaviour, socioeconomic status (family, neighbourhood and school), ethnic density (neighbourhood and school) and school type. None of the acculturation measures or subjective neighbourhood measures were related to body size in any of the models for either boys or girls and so are not discussed further.

Table 7.2 Summary of results from univariate and multivariate models

Key to table:

X =significant association ($p<0.05$), with specific quartile given where relevant

− = no significant association

First symbol represents when each variable was added individually to baseline model

Second symbol represents fully adjusted models

Variable	Boys BMI SDS	Boys Waist SDS	Girls BMI SDS	Girls Waist SDS
Individual behaviour				
Fruit and vegetable consumption	− −	− −	X X	− −
Skipping breakfast	X X	X X	X X	X X
Number of activity sessions	− −	X (Q3) X (Q3)	X(Q4) −	X (Q4) X (Q4)
Smoking	− −	− −	− −	− X
Parental behaviour				
Mum overweight	X X	X X	X X	X X
Mum smoking	− −	− −	− −	X X
Dad overweight	− −	− −	− −	− −
Dad smoking	− −	− −	− −	− −
Family SES				
Standard of living	X (Q4) X (Q4)	− X (Q4)	− −	− −
Family type/parental employment	− −	− X	− −	− −
Acculturation				
Generational status	− −	− −	− −	− −
Friends' ethnicity	− −	− −	− −	− −
Subjective Neighbourhood				
Like area	− −	− −	− −	− −
Safe during day	− −	− −	− −	− −
Safe at night	− −	− −	− −	− −
Good area	− −	− −	− −	− −
Objective Neighbourhood				
Deprivation	− −	− −	− −	X −
Own ethnic density				
White UK	− −	X X	− −	− −
Black Caribbean	− −	− −	− −	− −
Nigerian/Ghanaian	− −	− −	X −	− −
Other African	− −	− −	− −	− −
Indian	− −	− −	− −	− −
Pakistani/Bangladeshi	− −	− −	− −	− X
School				
Religion	− −	− −	X X	− −
Sex	− −	− −	X −	− −
Academic Performance	− X	− −	− X	− X (Q2)
Unauthorised absence	− −	X(Q4) X (Q2)	− −	X(Q4) X (Q2,3,4)
Own ethnic density				
White UK	− −	X(Q4) −	− −	− −
Black Caribbean	− −	− −	− −	− X
Nigerian/Ghanaian	− −	− −	− −	− −
Other African	− −	− −	X (Q3,4) −	X (Q4) −
Indian	− −	X(Q3) X	− −	− −
Pakistani/Bangladeshi	X(Q4) −	X(Q4) X	− X	− −

Individual behaviours and Body Size

The association between skipping breakfast and body size was unaffected by adjustment for the other individual, family, neighbourhood and school factors; the effect sizes remained consistent across all models. Compared to those who reported eating breakfast everyday, girls who reported skipping breakfast had a higher mean BMI SDS (0.36, 0.24 to 0.48) and Waist SDS (0.27, 0.14 to 0.39). The equivalent figures for boys were 0.34 (0.21 to 0.46) for BMI SDS and 0.25 (0.14 to 0.37) for Waist SDS. The finding that girls who ate <1 portion of fruit or vegetables per day had significantly a lower BMI SDS than those who ate ≥5 portions per day (-0.08, -0.14 to -0.01) was also not explained by the addition of further covariates to the model.

Compared to girls who reported the lowest number of activity sessions (Q1), girls reporting the most activity sessions (Q4) had a significantly higher mean Waist SDS (0.12, 0.02 to 0.23), with the effect size being similar to that obtained in the univariate models. In contrast, for boys there was a suggestion of more activity sessions being associated with a smaller waist but the difference was only statistically significant for those in Q3 [(Q2 -0.07, -0.15 to 0.01; Q3 -0.09, -0.18 to -0.01 and Q4 -0.07, -0.16 to 0.03)]. For both boys and girls, and for both body size measures, the effect sizes were unaffected with the addition of further variables to the models.

Parental behaviours

Having an overweight mother remained a significant correlate of both body size measures for both boys and girls, with the effect sizes remaining consistent with the addition of further variables to the models. Girls with overweight mothers had a higher mean BMI SDS (0.09, 0.01 to 0.18) and Waist SDS (0.22, 0.09 to 0.35) than those who reported that their mother was not overweight. The equivalent figures for boys were 0.12 (0.02 to 0.23) for BMI SDS and 0.19 (0.06 to 0.32) for Waist SDS.

Among girls, maternal smoking was associated with a significantly higher mean Waist SDS (0.26, 0.11 to 0.41); the association for BMI was in the same direction but not statistically significant (0.10, -0.01 to 0.21). This effect on waist was unaffected by the addition of further variables to the model.

Socioeconomic Status and Body Size

SES was measured at three levels; family, neighbourhood and school. The family SES measures (standard of living items, and family type/employment) were the first to be added

(Model 1). There was no association between the standard of living quartiles or family type/parental employment and either body size measure for the girls in any of the models. Boys in the most deprived standard of living items category (Q4) had a lower BMI SDS (-0.10, -0.19 to -0.01) and Waist SDS (-0.10, -0.21 to 0.02) than the least deprived boys (Q1). However there was no difference between those in Q2 or Q3 and Q1. The addition of further covariates to the models resulted in the Waist SDS difference between boys in Q1 and those in Q4 reaching statistical significance.

The association for boys between family type/parental employment and Waist SDS reached significance in Model 4 (adjusting for the baseline covariates plus family SES, acculturation, pupil behaviours, and parental behaviours); compared to boys in two parent working families, those in one parent working families had Waist SD scores 0.20 (0.02 to 0.38) higher and the direction of effect was the same for those in one parent non-working families (0.18, -0.01 to 0.37). The larger mean waist of those in one parent families (both working and non working) remained with the addition of further covariates to the model. There was no difference in body size between boys in two parent working families and those in two parent non-working families.

Neighbourhood deprivation, added in Model 6, was not a significant correlate of either body size measure for either boys or girls. The addition of further variables had little impact on the neighbourhood deprivation coefficients. In Model 8 the two measures of school-level SES, academic performance and unauthorised absence, were included. Compared to boys in the highest performing schools academically (Q1), those in Q2 (0.17, 0.02 to 0.32), Q3 (0.23, 0.06 to 0.40) and Q4 (0.21, 0.04 to 0.37) had significantly higher mean BMI SD scores. This association remained after further adjustment for school ethnic density (Model 10). In contrast to the boys, girls attending lower academic performance schools had lower mean BMI SD scores than those in the highest performance schools (Q1); Q2 (-0.12, -0.23 to -0.00), Q3 (-0.15, -0.28 to -0.01) and Q4 (-0.12, -0.26 to -0.03). However the addition of the school type variables to the model (Model 11) attenuated these relationships such that none of the BMI differences were statistically significant.

For boys, compared to those in schools with the lowest absence (Q1), those in schools with higher absence rates had slightly lower mean BMIs, but this only just reached statistical significance for those in Q3 (-0.08, -0.17 to -0.00). There was no clear pattern for the association between unauthorised absence and Waist SDS for boys. For girls, increasing unauthorised absence rates were associated with an increase in Waist SDS; after adjustment for school type and ethnic density (Model 11) all quartiles became significantly higher than Q1 [Q2 (0.16, 0.02 to 0.30); Q3 (0.18, 0.02 to 0.33); Q4 (0.36, 0.19 to 0.52)]. However this pattern was not observed for BMI SDS for girls.

Own Ethnic Density and Body Size

Own ethnic density was included at both the neighbourhood (Model 6) and school level (Model 9). These were included as binary variables; low density (Q1,2,3) vs. high density (Q4). Pakistani/Bangladeshi girls in high own density neighbourhoods had a larger mean Waist SDS (0.46, 0.00 to 0.91) than those in low density neighbourhoods. However this association was attenuated with the addition of school ethnic density to the model [e.g. 0.37 (-0.10 to 0.85) in Model 10]. There was a suggestion that greater own ethnic density could also be associated with a larger Waist SDS for Indian boys (0.31, -0.02 to 0.64) and a larger BMI SDS for Other African boys (0.28, -0.01 to 0.57) after adjustment for school SES and ethnic density (Model 10). In contrast, high own ethnic density was associated with a smaller Waist SDS for the White UK boys; this association remained significant after adjustment for neighbourhood SES and school sex and religion (-0.23, -0.47 to -0.00) but was attenuated after further adjustment for school SES and ethnic density [-0.15, (-0.40 to -0.11) in Model 10]. In the baseline models, greater Black African density was associated with a greater BMI SDS for Nigerian/Ghanaian girls. However in these multivariate models this association was not observed.

Greater own ethnic density at school was associated with a smaller body size for Black Caribbean girls, Indian boys, and Pakistani/Bangladeshi boys. Black Caribbean girls in high own density schools had a smaller Waist SDS (-0.25, -0.45 to -0.04) and BMI SDS (-0.12, -0.26 to 0.01) than those in low density schools. Similarly Indian boys attending schools with high own density had a lower mean Waist SDS (-0.41, -0.71 to -0.12) than those in low density schools and the direction of effect was the same for BMI SDS (-0.17, -0.41 to 0.06); and Pakistani/Bangladeshi boys who attended high density Pakistani/Bangladeshi schools also had a significantly smaller mean waist than those in low density schools (-0.40, -0.71 to -0.10). Further adjustment for school SES attenuated this association for Pakistani/Bangladeshi boys (-0.28, -0.60 to 0.04) but the significantly smaller waists of the Black Caribbean girls and Indian boys remained. In contrast, high own ethnic density was associated with a larger mean BMI SDS for Pakistani/Bangladeshi girls (0.37, 0.08 to 0.67). This relationship was unaffected by school SES. When added to the baseline models Black African density was a significant correlate of both Waist SDS and BMI SDS for the Other African girls but this association was not observed in the fully adjusted models; therefore adjustment for neighbourhood own ethnic density and the other measures attenuated this relationship.

School Type

School sex and school religion were entered into the models simultaneously (Model 7). Girls in Catholic schools had significantly higher BMIs than those in non-denominational schools (0.21, 0.02 to 0.40) but this was not seen for Waist SDS (0.08, -0.19 to 0.35). The significantly higher mean BMI of those in Catholic schools remained after further adjustment for school SES and ethnic density (Model 11). There was no difference in body size between girls in Church of England schools compared to those in non-denominational schools. Girls in single sex schools had borderline higher BMIs (0.15, -0.01 to 0.30) and waists (0.18, -0.04 to 0.41) than those in mixed sex schools. School type was not associated with body size for boys.

7.1.2 Selection of 'final' model

Due to the number of schools in the models (40 for boys, 41 for girls), it was important to consider whether the number of school-level variables included in some of the models pushed the statistical limits too far. For example, Model 11 for the girls included 5 school-level variables, more than would generally be recommended for 41 upper-level units. Further inspection of the total variance explained by each of the models revealed that some of the models may have had difficulty reaching accurate estimations (Boys Table 7.3; Girls Table 7.4); the proportion of total variance explained was sometimes lower after an additional variable had been added to the model, rather than higher as would be expected (with the addition of variables to a model the amount of total variance should stay constant or decrease). Therefore each of the school-level variables was carefully considered for inclusion. To be included, each variable/group of school variables had to be significantly associated with the outcome ($p<0.05$) and/or had to contribute to the total variance of a model in the expected way.

Table 7.3 Boys - Proportion of variance explained at each level by model

(final model selected shaded in grey)

		% Variance Explained in each Model									
Level of Model	Variance (baseline model)	Model 1 (Baseline +SES)	Model 2 (1+ Acculturation)	Model 3 (2+Individual behaviours)	Model 4 (3+Parental behaviours)	Model 5 (4+Subjective neighbourhood)	Model 6 (5+Objective neighbourhood)	Model 7 (6+school type)	Model 8 (6+school SES)	Model 9 (6+school ethnic density)	Model 10 (6+school SES & ethnic density)
BMI SDS											
School	0.006	-3.16	-3.26	34.35	35.96	33.79	51.97	43.97	100.00	79.90	100.00
Individual	1.517	-0.01	-0.01	1.51	2.04	2.05	2.09	2.06	2.12	2.14	2.29
Measure	0.239	0.23	0.31	0.23	-0.19	-0.28	-0.29	-0.30	-0.33	-2.06	-0.50
Total	1.762	0.01	0.02	1.44	1.85	1.83	1.93	1.87	2.10	1.82	2.22
Waist SDS											
School	0.022	2.27	1.36	1.31	-0.24	1.83	9.21	5.46	-2.31	12.47	-4.81
Individual	1.055	-0.27	-0.28	1.02	2.18	2.25	2.34	2.35	1.83	2.16	1.69
Measure	0.479	0.22	0.18	0.33	0.01	-0.10	-0.13	-0.12	1.56	0.36	1.86
Total	1.556	-0.08	-0.12	0.81	1.48	1.52	1.68	1.64	1.69	1.75	1.65

Table 7.4 Girls - Proportion of variance explained at each level by model

(final model selected shaded in grey)

Level of Model	Variance (baseline model)	% Variance Explained in each Model											
		Model 1 (Baseline +SES)	Model 2 (1+ Acculturation)	Model 3 (2+Individual behaviours)	Model 4 (3+Parental behaviours)	Model 5 (4+Subj. neigh.)	Model 6 (5+Obj. neigh.)	Model 7 (6+sch. type)	Model 8 (6+school SES)	Model 9 (6+school ethnic density)	Model 10 (6+school SES & ethnic density)	Model 11 (6+school type, SES & ethnic density)	Model 12 (6+school type & ethnic density)
BMI SDS													
School	0.015	-0.68	-6.11	-9.10	-15.32	-18.70	-19.21	66.65	-10.61	-1.62	12.74	65.40	75.31
Individual	1.317	0.03	-0.06	2.31	3.47	3.42	3.53	3.48	3.52	3.30	3.30	3.33	3.29
Measure	0.186	-0.25	-0.16	0.00	-0.75	-0.74	-0.82	-0.83	-0.93	-0.23	-0.34	-0.43	-0.24
Total	1.517	-0.01	-0.13	1.92	2.77	2.70	2.78	3.56	2.84	2.82	2.94	3.47	3.55
Waist SDS													
School	0.036	-1.69	-3.80	-9.93	-13.65	-16.69	-17.71	-10.45	-5.16	-10.49	1.99	-3.19	/
Individual	1.245	0.20	-0.01	1.56	4.41	4.62	4.36	4.38	4.18	4.21	3.93	3.99	/
Measure	0.504	-0.41	-0.25	-0.17	-1.13	-1.27	-0.96	-0.98	-0.28	-0.75	0.13	0.20	/
Total	1.785	-0.01	-0.16	0.84	2.48	2.52	2.41	2.56	2.73	2.51	2.82	2.77	/

For boys, none of the school-level variables significantly improved the BMI SDS model fit. Model 7 (school type) and Model 9 (ethnic density) explained less of the total variance than Model 6, suggesting estimation problems. Model 8 (SES) and Model 10 (ethnic density and SES) explained similar proportions of variance to each other at each level in the model; Model 8 was selected as there was no justification for selecting the more complex Model 10. For Waist SDS, the school SES variables (academic performance and absenteeism) ($p<0.001$) and school ethnic density ($p<0.05$) both improved the Waist SDS model when entered individually (Models 8 and 9 respectively), however school type (religion and sex) did not ($p=0.59$, Model 7). When the SES and ethnic density variables were added simultaneously (Model 10), SES remained significant but ethnic density did not. The proportion of variance explained by Models 8 and 10 was examined in order to select which of these best fit the data (i.e. was there justification for including school ethnic density in addition to SES). The total variance explained by Model 10 was actually slightly less than Model 8 (1.65% versus 1.69%). This suggests the model had difficulty producing accurate estimations. Model 8 was selected as the best choice to represent the boys Waist SDS data. Therefore Model 8 was chosen for both Waist SDS and BMI SDS for boys.

For girls, school type ($p<0.01$) and ethnic density ($p<0.05$) improved the BMI SDS model when added individually (Models 7 and 9 respectively). School SES did not ($p=0.55$, Model 8). When all three were added together (Model 11) both school type and ethnic density remained significant, so SES was removed from this model. The resulting model (Model 12) explained 3.55% of the total variance; slightly lower than the 3.56% explained by Model 7 but this was thought to be acceptable given that ethnic density significantly improved the model independent of school type. (The proportions explained at the other levels were: school 75.31%; individual 3.29%; measurement -0.24%). For Waist SDS, school SES ($p<0.01$) was the only school-level variable to improve the model. A comparison of the variances favoured Model 10; the total amount of variance explained was the highest of any of the Waist SDS models.

To summarise, both of the boys' models include two school-level variables, and the girls' models both include three (Table 7.5); given the number of schools (40 for boys, 41 for girls) these are appropriate numbers.

Table 7.5 Summary of final body size models for boys and girls

	Model Selected	School Level Variables Included in final model
Boys		
BMI SDS	Model 8	SES (academic performance, absenteeism)
Waist SDS	Model 8	SES (academic performance, absenteeism)
Girls		
BMI SDS	Model 12	Ethnic Density, Type (sex, religion)
Waist SDS	Model 10	Ethnic Density, SES (academic performance, absenteeism)

7.1.3 Ethnic differences by age in fully adjusted models

For each of the chosen models (Table 7.5) ethnic differences by age were examined. For ease of interpretation, results are presented in figures. These are in the same format as those presented in Chapter 3; the White UK group is the reference. For both BMI SDS and Waist SDS two models are shown:

1. The baseline model (as in Anthropometry Chapter; reproduced here to aid comparison).

2. The fully-adjusted model (adjusting for individual, family, neighbourhood and school variables).

Furthermore, the details (coefficients and 95% CI) of the differences between each ethnic group relative to the White UK group are presented for BMI SDS and Waist SDS for the baseline and final models in the Appendix (Boys BMI SDS Table 8.7; Boys Waist SDS Table 8.8; Girls BMI SDS Table 8.9; Girls Waist SDS Table 8.10).

7.1.3.1 Boys BMI SDS

The results presented in the anthropometry chapter showed that ethnic differences in BMI SDS emerged with increasing age for the boys; at 11.5yrs there were no significant ethnic differences but the Black Caribbean boys had significantly higher BMIs from 13.5yrs, and the Nigerian/Ghanaian boys from 14yrs, relative to the White UK boys. After adjustment for individual, family, neighbourhood and school factors, the White UK boys had the highest mean BMI SDS at 11.5 years but the Black Caribbeans and Nigerian/Ghanaians still had the most rapid increase in mean BMI with increasing age, such that they had significantly higher BMIs than the White UK boys from 15yrs onwards (an older age than was observed in the baseline model) (Figure 7.1). By 16yrs the Black Caribbeans had a mean BMI SD score 0.31 (0.11 to 0.52) higher than the White UK boys in the fully adjusted model [compared to 0.42 (0.23 to 0.61) in the baseline model]. The equivalent figures for the Nigerian/Ghanaians were 0.34 (0.08 to 0.60) and 0.41 (0.18 to 0.64) respectively.

In the baseline model, the Indian boys had BMI SD scores significantly lower than the White UK boys from 12yrs. In the fully adjusted models the difference between these two ethnic groups was not significant until 13yrs. The ethnic differences at 16yrs were similar in both models; the Indian boys had a mean BMI SD score -0.38 (-0.60 to -0.16) lower than the White UK boys in the baseline model compared to -0.41SD (-0.65 to -0.17) lower in the fully adjusted model.

BMI SDS differences between the White UK, Pakistani/Bangladeshi and Other African boys were not significant at any age in either model. However adjustment for the individual, family, neighbourhood and school factors increased ethnic differences for the Other Africans relative to the White UK. At 16yrs in the baseline model, the Other Africans had mean BMI SD score similar to the White UK group [-0.01SD (-0.23 to 0.22) lower] but in the fully adjusted model it was -0.16SD (-0.42 to 0.10) lower. It is notable that in the fully adjusted model the difference between the Other Africans and the Nigerian/Ghanaians and Black Caribbeans was larger than in the baseline model.

7.1.3.2 Boys Waist SDS

The White UK boys had the largest waists between 12.5yrs and 15.5yrs in the baseline model. The Other African boys had significantly smaller waists than the White UK boys at all ages. The Nigerian/Ghanaian boys had significantly smaller waists in early adolescence (11.5yrs to 13.5yrs). After adjusting for individual, family, school, and neighbourhood characteristics, the difference between the White UK boys and the Other African and Nigerian/Ghanaian boys increased (Figure 7.2). At 11.5yrs, the Other African boys had a mean Waist SDS -0.41 (-0.68 to 0.14) smaller in the fully adjusted model compared to -0.31 (-0.55 to -0.08) in the baseline model. By 16yrs, the equivalent figures were -0.36 (-0.62 to -0.10) and -0.24 (-0.46 to -0.02) respectively. In both models, the Nigerian/Ghanaians had significantly smaller waists than the White UK boys up to 14yrs. Adjustment for the range of covariates also increased ethnic differences between the Black Caribbean and the White UK boys; there were no significant differences in the baseline model but in the fully adjusted model the Black Caribbean boys' waists were significantly smaller between 12.5yrs and 14.5yrs. The Indian boys had significantly smaller waists at

15.5yrs to 16yrs in the baseline model and 15 to 16yrs in the fully adjusted model. The difference between the Pakistani/Bangladeshi boys and the White UK boys changed little between the models.

7.1.3.3 Girls BMI SDS

In the baseline model, Black Caribbean and Nigerian/Ghanaian girls had the highest BMIs, followed by the Other Africans; all three of these groups had significantly higher mean BMI SD scores than the other groups at all ages. In the fully adjusted model there was no longer any significant BMI SDS difference between the Other African girls and the White UK girls at any age (Figure 7.3). For example, at 16yrs in the baseline model the Other African girls had a mean BMI SDS 0.32SD (0.09 to 0.55) higher than the White UK girls but the difference was non-significant in the fully adjusted model (0.13SD, -0.14 to 0.40). The difference between the Nigerian/Ghanaian and White UK girls was attenuated in the fully adjusted model so that the difference only became statistically significant at 14.5yrs. There was less impact on the Black Caribbeans; their BMIs remained significantly higher than the White UK girls in both models at all ages. Similarly, there was little impact on the difference between the Indians and the White UK girls apart from a slight reduction at the youngest ages.

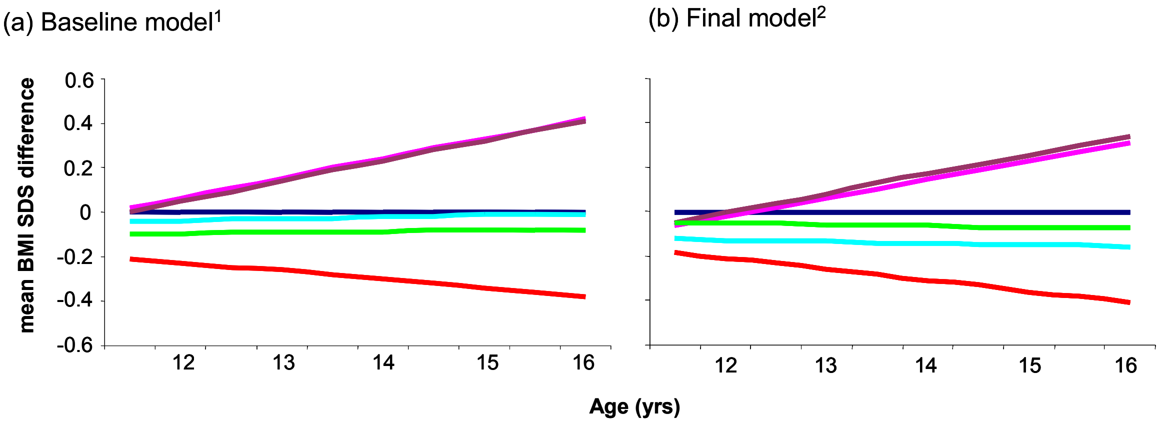
It was for the Pakistani/Bangladeshis that adjustment for the full range of covariates had the largest impact; ethnic differences increased between the baseline and the fully adjusted model. In the baseline model ethnic differences were not significant at any age, whereas in the fully adjusted model Pakistani/Bangladeshis had significantly lower BMIs than the White UK girls from 11.5yrs to 13yrs. For example at 11.5yrs in the fully adjusted model the Pakistani/Bangladeshi girls' BMI SDS was -0.30 (-0.59 to -0.01) lower than the White UK girls, compared to -0.13 (-0.39 to 0.13) in the baseline model.

7.1.3.4 Girls Waist SDS

In the baseline model the Black Caribbean girls had a significantly higher Waist SDS from 13 to 14.5yrs. These ethnic differences were slightly attenuated in the fully adjusted models so that they were significant from 13.5 to 14.5yrs (Figure 7.4). The Nigerian/Ghanaian girls also had significantly greater waists than the White UK at these ages in the baseline model (13.5 to 14.5yrs) but there were no significant differences in the fully adjusted model at any age. The Other Africans had waists of a similar size to the White UK girls in both models.

The Indian girls had smaller waists than the White UK girls from 12.5yrs onwards in the baseline model, significantly so from 14.5 to 15.5yrs. However in the fully adjusted model their mean waist was not smaller than the White UK girls' until 13.5yrs and the difference was not statistically significant at any age. In contrast, the difference between the White UK and Pakistani/Bangladeshi girls increased at all ages with adjustment for the covariates. In both models, the Pakistani/Bangladeshis had smaller waists than their White UK peers at all ages, the difference was statistically significant at 15.5 and 16yrs in the baseline model and 15 to 16yrs in the fully adjusted model. It is notable that in the baseline model the Pakistani/Bangladeshis girls had the smallest waists at all ages.

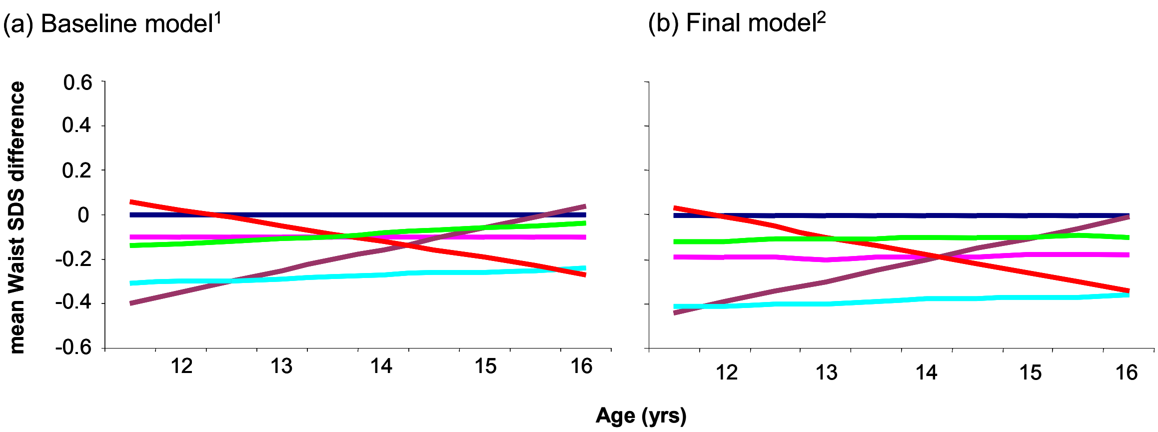
Figure 7.1 Boys BMI SDS: Ethnic differences by age relative to White UK



1Baseline Model: age, age^2, height SDS, pubertal status

2Final Model: age, age^2, height SDS, pubertal status, individual SES (standard of living; family type/parental employment), acculturation (generational status, friends' ethnicity), individual behaviours (activity sessions, skipping breakfast, fruit and vegetable intake, smoking status), parental behaviours (mum overweight, mum smoking, dad overweight, dad smoking), neighbourhood (deprivation, ethnic density), and school SES (academic performance, absenteeism)

Figure 7.2 Boys Waist SDS: Ethnic differences by age relative to White UK



[1]Baseline Model: age, age^2, height SDS, pubertal status

[2]Final Model: age, age^2, height SDS, pubertal status, individual SES (standard of living; family type/parental employment), acculturation (generational status, friends' ethnicity), individual behaviours (activity sessions, skipping breakfast, fruit and vegetable intake, smoking status), parental behaviours (mum overweight, mum smoking, dad overweight, dad smoking), neighbourhood (deprivation, ethnic density), and school SES (academic performance, absenteeism)

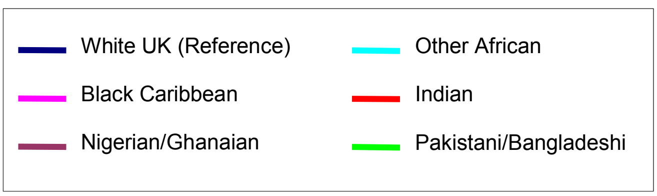
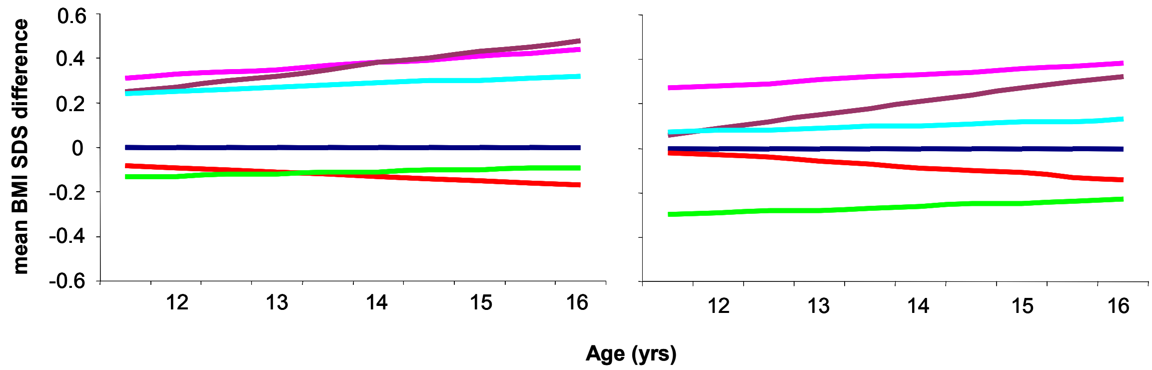


Figure 7.3 Girls BMI SDS: Ethnic differences by age relative to White UK

(a) Baseline model[1] (b) Final model[2]

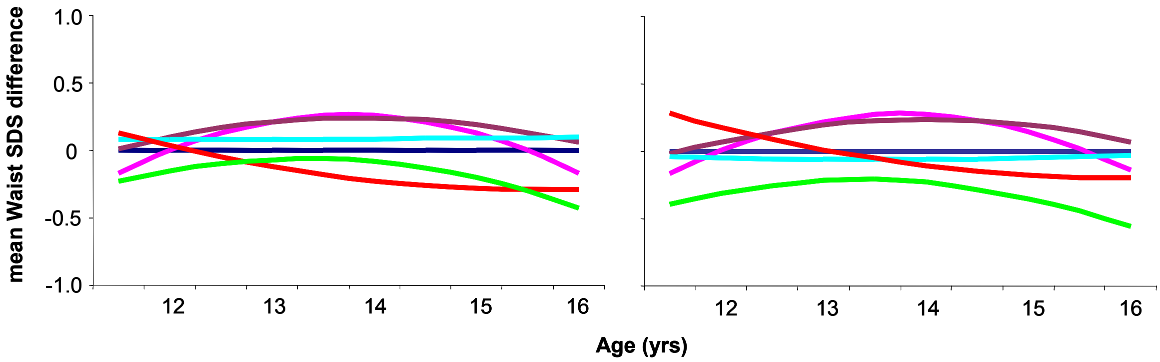


[1]Baseline Model: age, age^2, height SDS, pubertal status

[2]Final Model: age, age^2, height SDS, pubertal status, individual SES (standard of living; family type/parental employment), acculturation (generational status, friends' ethnicity), individual behaviours (activity sessions, skipping breakfast, fruit and vegetable intake, smoking status), parental behaviours (mum overweight, mum smoking, dad overweight, dad smoking), neighbourhood (deprivation, ethnic density), school type (sex, religion) and school ethnic density

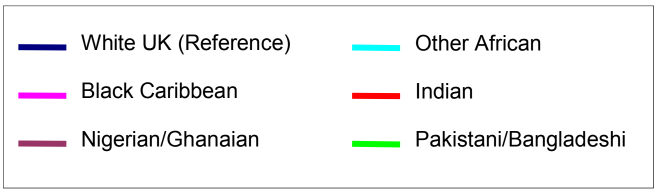
Figure 7.4 Girls Waist SDS: Ethnic differences by age relative to White UK

(a) Baseline model[1] (b) Final model[2]



[1]Baseline Model: age, age^2, age^3, height SDS, pubertal status

[2]Final Model: age, age^2, age^3, height SDS, pubertal status, individual SES (standard of living; family type/parental employment), acculturation (generational status, friends' ethnicity), individual behaviours (activity sessions, skipping breakfast, fruit and vegetable intake, smoking status), parental behaviours (mum overweight, mum smoking, dad overweight, dad smoking), neighbourhood (deprivation, ethnic density), school SES (academic performance, absenteeism) and school ethnic density



7.1.4 Assessment of significant interactions

The final models assume that the association between each of the covariates and body size is the same for every ethnic group. The results presented in the previous chapters have shown that this was often not the case. Therefore interaction terms between ethnicity and every other covariate in the final model were tested, one at a time, to determine their significance. It was also of interest to determine whether there were interactions between the different measures of deprivation i.e. school deprivation x individual deprivation; school deprivation x neighbourhood deprivation; and neighbourhood deprivation x individual deprivation. Finally, interactions between neighbourhood deprivation and neighbourhood ethnic density, and school deprivation and school ethnic density were assessed. Only a few of the many interactions tested were statistically significant (p<0.05) and these are summarised in Table 7.6 and described in more detail in the text.

Table 7.6 Summary of significant interaction in final models

	Boys		Girls	
	BMI SDS	Waist SDS	BMI SDS	Waist SDS
Interaction				
Ethnicity*PA sessions	P=0.04			
Ethnicity*Breakfast			P=0.04	
Ethnicity*student smoking	P<0.01			
Ethnicity*standard of living	P=0.04			
Ethnicity*friend's ethnicity		P=0.02	P=0.03	
Ethnicity*School academic achievement				P=0.02
IMD*Unauthorised absence				P=0.02

For three of the interactions none of the individual components of the interaction term were significant (ethnicity*standard of living, ethnicity*school academic achievement, and neighbourhood deprivation*unauthorised absence). Therefore these are not discussed further.

The interaction between ethnicity and physical activity sessions was significant for BMI SDS for boys. For Other Africans in Q2 and Q3, the coefficients were significantly less than 0; therefore for this group the joint effect of these variables was less than if the two variables were considered independently (Table 7.7). This means that the impact of being in Q2 or Q3 on BMI for Other African boys was significantly less than it was for White UK boys. Similarly, the impact of Other African ethnicity on BMI was less for boys in Q2 and Q3 than it was for those doing the lowest number of sessions (Q1). None of the other components of this interaction was statistically significant.

Table 7.7 Summary of interaction between Ethnicity and PA Sessions for Boys BMI SDS

Ethnicity (White UK=Ref)	PA Sessions (Q1 least= Ref)	Coefficient (95% CI)
Black Caribbean	Q2	0.06 (-0.11-0.24)
	Q3	0.09 (-0.10-0.27)
	Q4	0.09 (-0.12-0.30)
Nigerian/Ghanaian	Q2	0.07 (-0.17-0.31)
	Q3	-0.13 (-0.36-0.11)
	Q4	-0.08 (-0.34-0.18)
Other African	Q2	-0.26 (-0.47--0.05)*
	Q3	-0.31 (-0.54--0.09)*
	Q4	-0.18 (-0.43-0.06)
Indian	Q2	0.16 (-0.05-0.36)
	Q3	-0.08 (-0.30-0.14)
	Q4	-0.05 (-0.30-0.20)
Pakistani/Bangladeshi	Q2	-0.05 (-0.24-0.14)
	Q3	-0.10 (-0.31-0.10)
	Q4	-0.01 (-0.23-0.21)

The interaction between ethnicity and breakfast was significant for BMI SDS for girls. Skipping breakfast was associated with a significantly larger increase in BMI SDS for Pakistani/Bangladeshi girls than White girls; similarly Pakistani/Bangladeshi ethnicity was associated with an increase in BMI SDS for those who skipped breakfast compared to those who did not (i.e. ethnicity and breakfast had a synergistic effect for this ethnic group) (Table 7.8).

Table 7.8 Summary of interaction between Ethnicity and Skipping breakfast for Girls BMI SDS

Ethnicity (White UK ref)	Coefficient (95% CI) of skipping breakfast
Black Caribbean	0.17 (-0.17-0.51)
Nigerian/Ghanaian	0.05 (-0.31-0.42)
Other African	-0.31 (-0.73-0.12)
Indian	0.13 (-0.31-0.57)
Pakistani/Bangladeshi	0.56 (0.10-1.02)*

For boys’ BMI SDS there was a significant interaction between smoking status and ethnicity. The interaction was synergistic (i.e. the effect of ethnicity and smoking status was significantly greater for the variables combined than if they were considered individually) for the Nigerian/Ghanaian, Other African, and Pakistani/Bangladeshi smokers, and for the Indian and Pakistani/Bangladeshi boys who had given up (Table 7.9). However numbers were often small in these categories and so it is important not to over interpret results.

Table 7.9 Summary of interaction between Ethnicity and Smoking for Boys BMI SDS

Ethnicity (White UK=Ref)	Smoking Status (Never=Ref)	Coefficient (95% CI)
Black Caribbean	Tried Once	-0.07 (-0.24-0.10)
	Given-Up	-0.03 (-0.39-0.33)
	Smoker	-0.04 (-0.36-0.29)
Nigerian/Ghanaian	Tried Once	0.02 (-0.23-0.26)
	Given-Up	0.27 (-0.45-0.99)
	Smoker	0.89 (0.18-1.59)*
Other African	Tried Once	0.07 (-0.15-0.29)
	Given-Up	-0.12 (-0.58-0.35)
	Smoker	0.84 (0.31-1.38)*
Indian	Tried Once	0.01 (-0.23-0.25)
	Given-Up	0.62 (0.07-1.18)*
	Smoker	-0.05 (-0.47-0.36)
Pakistani/Bangladeshi	Tried Once	-0.07 (-0.26-0.13)
	Given-Up	0.41 (0.03-0.79)*
	Smoker	0.33 (0.03-0.64)*

There was a significant interaction between ethnicity and friends' ethnicity for Waist SDS for boys and BMI SDS for girls. For Indian boys who said most of their friends were a different ethnicity to themselves, the interaction was significantly negative (Table 7.10). Similarly it was a negative interaction for Black Caribbean girls who said that most or some or none of their friends were a different ethnicity to themselves.

Table 7.10 Summary of interaction between Ethnicity and Friends' Ethnicity

Ethnicity	Friend's of different ethnicity (Ref: Quite a lot)	Coefficient (95% CI)
Boys - Waist SDS		
Black Caribbean	Most	0.20 (-0.16-0.56)
	Some or none	0.12 (-0.07-0.31)
Nigerian/Ghanaian	Most	-0.22 (-0.57-0.13)
	Some or none	-0.21 (-0.43-0.01)
Other African	Most	-0.01 (-0.36-0.33)
	Some or none	0.10 (-0.14-0.34)
Indian	Most	-0.52 (-0.89--0.15)*
	Some or none	-0.03 (-0.25-0.20)
Pakistani/Bangladeshi	Most	-0.22 (-0.55-0.10)
	Some or none	0.01 (-0.20-0.21)
Girls - BMI SDS		
Black Caribbean	Most	-0.25 (-0.50-0.00)
	Some or none	-0.19 (-0.32--0.05)*
Nigerian/Ghanaian	Most	-0.16 (-0.40-0.08)
	Some or none	0.02 (-0.12-0.17)
Other African	Most	-0.31 (-0.55--0.07)
	Some or none	-0.13 (-0.30-0.05)
Indian	Most	-0.23 (-0.49-0.03)
	Some or none	0.06 (-0.12-0.24)
Pakistani/Bangladeshi	Most	-0.26 (-0.52-0.01)
	Some or none	-0.10 (-0.30-0.09)

7.1.5 Key Points - BMI SDS and Waist SDS

- Adjustment for the range of individual, family, neighbourhood and school measures generally did not change the associations observed in the baseline analyses.

- Skipping breakfast and having an overweight mother remained significant correlates of both body size measures for both boys and girls.

- The associations between body size and the various measures of SES (at the family, neighbourhood and school level) were inconsistent (e.g. greater school deprivation was associated with an increase in BMI SDS for boys, but with a decrease for girls; neighbourhood deprivation was not significant for either gender; for boys, family disadvantage [standard of living] was associated with a decrease in body size but being in a one-parent family was associated with an increase in Waist SDS).

- There was a suggestion that greater neighbourhood own ethnic density was associated with an increase in BMI SDS for Other African boys and Waist SDS for Indian boys independent of individual, family and school characteristics, and neighbourhood deprivation, although these relationships did not reach statistical significance.

- Indian boys and Black Caribbean girls in schools with high own ethnic density had significantly smaller mean waists than those in lower density schools independent of other factors including neighbourhood ethnic density and school deprivation. In contrast greater school own ethnic density was associated with a significantly higher mean BMI SDS for Pakistani/Bangladeshi girls.

- Adjustment for the individual, family, neighbourhood and school variables attenuated some ethnic differences (e.g. White UK and Nigerian/Ghanaian and Other African girls' BMI SDS difference) but increased others (e.g. White UK and Other African boys' difference for both body size measures and White UK and Pakistani/Bangladeshi girls for both measures). However in general, the range of measures considered did not explain the ethnic differences in body size in adolescence.

7.2 Overweight and Obesity

The overweight/obesity models had a binary outcome (0=normal weight, 1=overweight or obese). The baseline overweight/obesity models adjusted for age, pubertal status and height (as was the case with the BMI SDS and Waist SDS models). The other covariates were then added using the same model building strategy as before (although only a selection of the models was chosen for pragmatic reasons: Models 1-4, 6 and 8 for boys, and Models 1-4, 6 and 12 for the girls). Firstly, significant associations between the individual, family, neighbourhood and school variables and overweight/obesity are described. How adjustment for these impacted on ethnic differences is then discussed.

7.2.1 Correlates of overweight/obesity

Full results tables for the overweight/obesity models are presented in the Appendix (boys Table 8.11; girls Table 8.12). A general finding from the logistic multilevel models was that estimates were imprecise; confidence intervals were often very wide. Therefore the results presented in this section should be interpreted in light of this. Those who skipped breakfast were significantly more likely to be overweight/obese [boys OR 3.89 (95% CI: 2.11 to 7.19); girls 5.78 (2.86 to 11.67)]. Adjustment for the other covariates did not attenuate these associations. Skipping breakfast was the only variable to be a significant correlate of overweight/obesity for both boys and girls.

Girls who reported eating <1 portion of fruit or vegetables per day had significantly lower odds of being overweight/obese than those eating ≥5 portions (0.43, 0.23 to 0.81). Similar to the pattern observed for BMI SDS, boys who reported having tried smoking once were more likely to be overweight/obese than those who had never tried (1.99, 1.20-3.29). In contrast, the association for girls was not significant. Compared to those who did the lowest number of physical activity sessions (Q1), boys in Q2 were significantly less likely to be overweight/obese (0.55, 0.32-0.93). Those in Q3 and Q4 were also less likely but not significantly so. For girls, the opposite pattern was observed; those in Q2, Q3, and Q4 all had odds ratios greater than 1, but none of the differences were statistically significant.

Having an overweight mother was a significant correlate for the girls (3.58, 1.60 to 8.04), but did not reach statistical significance for the boys (2.03, 0.93 to 4.43). Having a mother who smoked was borderline significant for the boys (2.13, 1.00 to 4.57) and in the same direction for the girls (1.98, 0.79-4.95). This pattern was not observed for fathers' smoking status. The acculturation measures and family SES were not associated with overweight/obesity.

Neighbourhood deprivation, subjective opinions of the neighbourhood, and school SES and type were not related to overweight/obesity. School and neighbourhood own ethnic density were significant only for Black Caribbean girls; those in high Black Caribbean density schools had significantly lower odds of being overweight/obese than those in lower density schools (0.27, 0.09-0.84) independent of neighbourhood own ethnic density. The neighbourhood ethnic density variables tended to have very wide confidence intervals, particularly for the girls; some upper confidence intervals being well over 100. Although there were few statistically significant associations between neighbourhood and school contexts and overweight/obesity in these models, the wide confidence intervals suggest we are lacking adequate power to detect such associations if they do exist.

7.2.2 Effect of adjustment on ethnic differences in overweight/obesity

As there was no significant interaction between ethnicity and age for overweight/obesity for the boys, the ethnic differences were constant across all ages and are presented in Table 7.11. Confidence intervals were wide and there were no significant ethnic differences relative to the White UK group. In general, ethnic differences changed little across the models. Compared to the baseline model, in the fully adjusted models ethnic differences relative to the White UK boys were slightly attenuated for the Black Caribbeans and Nigerian/Ghanaians, but increased slightly for the other ethnic groups although all differences remained non-significant.

There was a significant interaction between ethnicity and age for the girls, therefore ethnic differences are presented at 3 ages (12yrs, 14.5yrs and 16yrs) in Table 7.11 to give an indication of how differences changed with age. In the baseline models, the Black Caribbean girls were significantly more likely to be overweight/obese than the White UK girls at all ages, with the ethnic difference increasing with age. The Other African girls also had significantly higher odds at all ages but the magnitude of the difference decreased slightly as age increased. The Nigerian/Ghanaian girls were not more likely to be overweight/obese than the White UK girls at 12yrs but by 14.5yrs they were, and this ethnic difference continued to increase with age. There was no significant difference in overweight/obesity between the White UK girls and either the Indians or the

Pakistani/Bangladeshis at any age. Even in these baseline models, the confidence intervals were wide (for example OR15.56, 95%: 4.44-54.56 for Black Caribbean girls at 16yrs).

Given the inaccurate estimations, the impact of adjustment for the covariates on ethnic differences in overweight/obesity has to be interpreted with caution. For the Black Caribbeans, adjustment for the individual and family variables had little impact on the odds ratios but did result in estimates becoming less precise. Further adjustment for the neighbourhood and school variables increased the ethnic differences but also resulted in confidence intervals with upper limits of over 100. For the Nigerian/Ghanaians adjustment for the covariates slightly attenuated ethnic differences compared to the White UK girls. However in the fully adjusted model, the Nigerian/Ghanaians were still significantly more likely to be overweight/obese. Confidence intervals at 16yrs, and to a lesser extent 14.5yrs, became wider with the addition of covariates, however they were less affected at 12yrs. For the Other Africans, ethnic differences were also attenuated by the addition of the neighbourhood and school variables. This resulted in their odds of being overweight/obese not being significantly different to the White UK girls at any age in the fully adjusted model, although their odds were still higher and confidence intervals were wide.

The differences between the Indian and the White UK girls increased slightly with the addition of the individual, family, and neighbourhood covariates to the model. However they decreased again with further adjustment for the school variables, with the odds ratios in the fully adjusted models being similar to those of the baseline model. In contrast to some of the other ethnic groups, the magnitude of the confidence intervals changed little for the Indians with the addition of variables to the model. The difference between the Pakistani/Bangladeshis and the White UK girls changed little with the addition of covariates to the model; odds ratios were slightly lower in the fully adjusted model compared to the baseline.

Table 7.11 Ethnic differences in overweight/obesity

	Odds Ratios and 95% CI (White UK=1.00)			
	Boys	Girls		
	All ages	12yrs	14.5yrs	16yrs
Black Caribbean				
Baseline	1.90 (0.86-4.20)	13.37 (4.42-40.42)*	14.70 (5.44-39.74)*	15.56 (4.44-54.56)*
Model 1	1.90 (0.85-4.25)	13.82 (4.37-43.64)*	13.94 (4.90-39.70)*	14.02 (3.78-51.98)*
Model 2	1.95 (0.86-4.42)	13.89 (4.27-45.16)*	14.04 (4.78-41.20)*	14.12 (3.71-53.70)*
Model 3	1.80 (0.78-4.18)	11.37 (3.38-38.32)*	12.21 (3.94-37.79)*	12.68 (3.10-51.87)*
Model 4	2.13 (0.91-4.98)	13.54 (3.83-47.86)*	16.19 (4.89-53.62)*	18.03 (4.08-79.78)*
Model 6	1.70 (0.65-4.49)	20.22 (5.05-80.93)*	26.23 (6.19-111.11)*	21.73 (4.81-98.06)*
Model 8[1]	1.61 (0.61-4.28)			
Model 12[2]		25.15 (5.28-119.71)*	24.38 (5.91-100.63)*	25.37 (4.44-145.06)*
Nigerian/Ghanaian				
Baseline	1.26 (0.48-3.33)	2.42 (0.75-7.87)	8.51 (3.07-23.58)*	18.09 (5.04-64.87)*
Model 1	1.24 (0.47-3.30)	2.47 (0.74-8.30)	8.24 (2.88-23.56)*	16.97 (4.56-63.05)*
Model 2	1.21 (0.45-3.26)	2.48 (0.73-8.42)	8.33 (2.88-24.08)*	17.20 (4.58-64.63)*
Model 3	0.97 (0.34-2.76)	1.83 (0.52-6.50)	6.66 (2.14-20.73)*	14.40 (3.45-60.11)*
Model 4	1.30 (0.44-3.80)	2.45 (0.65-9.30)	9.18 (2.70-31.23)*	20.29 (4.43-92.92)*
Model 6	1.23 (0.36-4.18)	2.18 (0.51-9.33)	8.47 (2.00-35.84)*	16.02 (3.27-78.56)*
Model 8[1]	1.13 (0.33-3.85)			
Model 12[2]		1.13 (0.23-5.65)	5.03 (1.12-22.66)*	12.34 (1.94-78.53)*
Other African				
Baseline	0.73 (0.28-1.91)	11.21 (2.82-44.48)*	10.02 (2.84-35.33)*	9.37 (1.89-46.35)*
Model 1	0.67 (0.25-1.79)	12.92 (3.08-54.13)*	10.17 (2.75-37.71)*	8.82 (1.69-45.93)*
Model 2	0.65 (0.23-1.85)	13.28 (2.89-61.05)*	10.39 (2.54-42.52)*	8.96 (1.58-50.70)*
Model 3	0.53 (0.18-1.56)	11.19 (2.34-53.64)*	9.07 (2.07-39.81)*	7.97 (1.28-49.42)*
Model 4	0.68 (0.23-2.08)	16.17 (3.16-82.85)*	13.66 (2.85-65.36)*	12.34 (1.81-84.36)*
Model 6	0.51 (0.14-1.80)	9.21 (1.61-52.63)*	7.85 (1.28-48.25)*	6.50 (0.92-45.95)
Model 8[1]	0.48 (0.14-1.72)			
Model 12[2]		6.33 (0.90-44.69)	4.63 (0.77-27.92)	3.79 (0.41-34.96)
Indian				
Baseline	1.88 (0.75-4.74)	3.05 (0.87-10.68)	2.31 (0.67-7.96)	1.96 (0.37-10.32)
Model 1	1.86 (0.74-4.71)	3.48 (0.96-12.60)	2.39 (0.68-8.43)	1.90 (0.35-10.35)
Model 2	1.82 (0.72-4.64)	3.50 (0.95-12.86)	2.43 (0.67-8.76)	1.95 (0.35-10.85)
Model 3	2.18 (0.84-5.68)	3.61 (0.95-13.68)	2.63 (0.70-9.92)	2.18 (0.37-12.89)
Model 4	2.72 (1.01-7.32)*	4.54 (1.13-18.22)*	3.10 (0.76-12.66)	2.47 (0.38-16.07)
Model 6	2.27 (0.74-7.00)	5.36 (1.16-24.88)*	3.44 (0.67-17.68)	2.79 (0.41-19.20)
Model 8[1]	2.17 (0.69-6.77)			
Model 12[2]		3.50 (0.67-18.30)	2.33 (0.44-12.21)	1.78 (0.20-15.49)
Pakistani/Bangladeshi				
Baseline	1.77 (0.76-4.14)	1.17 (0.29-4.73)	1.81 (0.49-6.64)	2.34 (0.41-13.46)
Model 1	1.72 (0.73-4.08)	1.46 (0.34-6.30)	1.98 (0.51-7.68)	2.37 (0.39-14.38)
Model 2	1.69 (0.71-4.04)	1.47 (0.34-6.38)	2.43 (0.67-8.76)	2.40 (0.39-14.67)
Model 3	1.92 (0.79-4.71)	1.03 (0.22-4.77)	1.64 (0.39-7.01)	2.18 (0.32-14.92)
Model 4	2.40 (0.95-6.06)	1.08 (0.21-5.46)	1.95 (0.42-8.96)	2.78 (0.38-20.54)
Model 6	2.98 (1.03-8.58)*	0.77 (0.13-4.63)	1.39 (0.23-8.50)	1.98 (0.24-16.30)
Model 8[1]	2.84 (0.97-8.26)			
Model 12[2]		0.79 (0.11-5.44)	1.41 (0.23-8.63)	2.02 (0.20-20.36)

[1]Model 8 not run for girls

[2]Model 12 not run for boys

7.2.3 Key Points - Overweight and obesity

- Despite the imprecision of estimates, patterns of association between overweight/obesity and the covariates were generally similar to those observed for BMI SDS and Waist SDS.

- Skipping breakfast was associated with an increased risk of overweight/obesity for both boys and girls, and having an overweight mother for girls.

- For boys, none of the ethnic groups had odds of overweight/obesity significantly different to the White UK boys, and the magnitude of ethnic differences did not change with age.

- For the girls, the Black Caribbeans and Other Africans had the highest odds of being overweight/obese at 12yrs. Ethnic differences increased with age for the Black Caribbeans and Nigerian/Ghanaians, but stayed relatively constant for the Other Africans. By 16yrs, the Nigerian/Ghanaians and Black Caribbeans had the highest odds of overweight/obesity.

- Adjustment for the individual, family, neighbourhood and school variables attenuated some ethnic differences and increased others; however estimates were imprecise. The Other African girls no longer had a higher risk of overweight/obesity relative to the White UK girls in the fully adjusted model.

8 Discussion and conclusions

This is the first known study to have systematically examined a range of both school and neighbourhood characteristics on ethnic differences in body size in the UK. This chapter summarises the key findings and discusses how they compare with the existing literature. Strengths and limitations of the study are then highlighted, and finally potential policy implications are proposed.

8.1 Summary of key findings

The key findings for each of the main aims are summarised in Table 8.1. The key question addressed in this thesis concerned the impact of residential neighbourhoods and school context on ethnic differences in body size. Very little of the variation in body size was due to differences between neighbourhoods or schools. Individual and family characteristics were more important determinants of body size than neighbourhood or school variables. Individual factors such as age, ethnicity, pubertal status, height, and skipping breakfast, along with maternal overweight, were the strongest correlates of body size. Few of the neighbourhood and school variables considered were significant, and adjustment for them did not alter the relationships observed for the individual and family variables. An important finding was that adjustment for the range of individual, family, neighbourhood, and school variables in the fully adjusted final models only explained around 2% of the overall variance in BMI and Waist SDS. Overall, the individual, family, neighbourhood and school characteristics considered in this thesis did not explain ethnic differences in body size trends in adolescence.

Ethnic differences in BMI emerged for boys and persisted for girls between early and late adolescence; the Black Caribbean and Nigerian/Ghanaian boys and girls, and the Other African girls, had the highest mean BMIs. The Other African boys had a similar mean BMI to their White UK and Pakistani/Bangladeshi peers at all ages. The groups with the highest BMIs did not necessarily have the largest waists, highlighting ethnic differences in fat distribution or body composition. Mean BMI differences corresponded with those by overweight status for girls but not boys. Black Caribbean, Nigerian/Ghanaian and Other African girls had the highest proportions overweight, and the White UK the lowest. The Black Caribbeans had the highest proportions of obesity, followed by the

Nigerian/Ghanaians. Proportions were lowest for the Indian and Pakistani/Bangladeshi girls.

The DASH pupils overall, particularly the girls, had larger waists than the 1990 Growth Reference population at all ages. Therefore even groups such as the Indian and Pakistani/Bangladeshi girls, who had low BMIs and levels of obesity relative to their DASH peers, had more central adiposity than those in the reference population. With regards to the other measures (height, weight, and BMI) the DASH pupils in every ethnic group generally had a larger body size than the reference population in early adolescence (an exception being that Indian and Pakistani/Bangladeshi girls were not taller). There was a general trend for SD scores to fall with increasing age; however this trend varied by sex, ethnic group, and the measure itself.

Further to these main findings, an interesting result was that many of the ethnic minority pupils attended high performing schools relative to their White peers despite, with the exception of the Indians, being generally more likely to live in highly deprived areas. This challenges the conventional view point of all ethnic minority groups being uniformly deprived.

Table 8.1 Summary of overall thesis aims and findings

Research Aim	Key Findings
1. To examine ethnic differences in anthropometric measures between early and late adolescence. (Chapter 3)	**Height**: Black Caribbean, Nigerian/Ghanaian, and Other African pupils were the tallest in early adolescence. By late adolescence White UK pupils had a similar height to these groups, but Indians and Pakistani/Bangladeshis remained shorter. **BMI**: Ethnic differences emerged for boys and persisted for girls. Black Caribbean, Nigerian/Ghanaian, and Other African girls had a higher mean BMI than White UK girls. From mid to late adolescence, Black Caribbean and Nigerian/Ghanaian boys had a higher mean BMI than White UK boys. **Waist**: Ethnic patterning differed to that of BMI. There was little ethnic difference in mean waist circumference after adjustment for pubertal status and height for girls, but Other African boys had significantly smaller waists than the White UK boys at all ages.
2a. To determine what proportion of the variance in body size was due to differences between schools. 2b. To examine whether school characteristics were related to body size (adjusted for age, ethnicity, height and pubertal status). (Chapter 4)	Less than 4% of the variance in BMI or waist was due to differences between schools. Much of the between school variance was explained by pupil ethnicity. **School type**: Girls in Catholic and single sex schools had a higher mean BMI than those in mixed, non-denominational schools. **Own ethnic density**: Greater school own ethnic density associated with decrease in body size for White UK pupils and Pakistani/Bangladeshi boys, but with increase for Other African girls. **School SES**: Boys and girls in schools with highest unauthorised absence rates had larger waists than those in schools with low rates. **School ethos:** no association.
3a. To determine what	Less variation in body size between neighbourhoods (<1%) than between

proportion of the variance in body size was due to differences between neighbourhoods. 3b. To examine whether neighbourhood characteristics were related to body size (adjusted for age, ethnicity, height and pubertal status). (Chapter 5)	schools. **Own ethnic density**: Greater own residential density associated with decrease in body size for White UK boys and increase for Nigerian/Ghanaian girls. **Neighbourhood SES**: Girls who lived or attended school in more deprived areas had larger waists than those in the least deprived areas. **Crime/land use/perceptions of neighbourhood**: few or inconsistent findings.
4. To examine which individual and family characteristics were related to body size (adjusted for age, ethnicity, height, and pubertal status). (Chapter 6)	**Family SES**: Most deprived boys (standard of living items) significantly lower BMI than least deprived boys. No association with other SES measures. **Acculturation**: no association. **Individual behaviours**: Skipping breakfast associated with higher BMI and waist circumference for boys and girls. Girls who ate few fruit and vegetables had smaller body size than those who ate more. More sedentary time associated with greater body size for White UK girls only. **Parental behaviours**: Having overweight mother associated with higher BMI and waist circumference for boys and girls.
5a. To examine the effect of school and neighbourhood characteristics after adjustment for individual and family characteristics. 5b. To examine the effect of neighbourhood and school characteristics on ethnic differences in body size in fully adjusted models. (Chapter 7)	**Neighbourhood own ethnic density**: Suggestion that greater own neighbourhood density was associated with an increase in BMI SDS for Other African boys and Waist SDS for Indian boys. **School own ethnic density**: Indian boys and Black Caribbean girls in high own ethnic density schools had smaller mean waists than those in lower density schools, but Pakistani/Bangladeshi girls in high own ethnic schools had a higher mean BMI SDS. **School type**: Girls in Catholic schools had a higher mean BMI SDS than those in non-denominational schools. **SES**: Associations between the various SES measures (at individual, school, and neighbourhood level) and body size were inconsistent. **Individual/family**: Skipping breakfast and having an overweight mother were key correlates of both BMI and waist circumference. These associations were unaffected by adjustment for school and neighbourhood characteristics. Adjustment for the individual, family, school and neighbourhood characteristics generally did not explain ethnic differences in body size trends. Furthermore, the fully adjusted models explained only around 2% of the total variation in BMI SDS and Waist SDS.

8.2 Comparison with existing literature

8.2.1 Ethnic differences in body size

Relatively few studies have examined ethnic differences in body size at this age in the UK (El-Sayed et al., 2011). The most directly comparable studies to DASH are HABITS and RELACHS; both are also relatively recent London school-based studies of adolescents (further details in Chapter 1). However there are differences which limit comparisons. RELACHS has only published measures of body size at 11-14 years and focuses mainly on South Asians with relatively small numbers of Black Africans or Black Caribbeans.

HABITS is longitudinal and like DASH covers 11-16 years, but it uses broad White, Black, Asian categories (with both Black and Asian including ‘mixed’ individuals). Unlike DASH, these studies were not designed *a priori* to examine ethnic differences in body size.

Similar to DASH, both HABITS and RELACHS showed Black African/Caribbean pupils to be the tallest groups in early adolescence and RELACHS showed Bangladeshis and Pakistanis to be the shortest (Taylor et al., 2005, Wardle et al., 2006). As with DASH, HABITS showed greater ethnic differences in BMI and overweight/obesity for girls than boys; Black girls had higher BMIs, had larger waists, and were more likely to be overweight/obese compared to their White peers, whereas Asian girls had a lower mean BMI, smaller waists, and were less likely to be overweight/obese (Wardle et al., 2006). In contrast to DASH, ethnic differences for boys were not significant at any age. The proportion overweight decreased with age in DASH. HABITS also showed that overweight decreased with age but obesity increased. In contrast to DASH and HABITS, in RELACHS Indian boys were the only group to be significantly more likely to be overweight than their White peers. Furthermore there were no significant ethnic differences in obesity (Taylor et al., 2005).

In a recent London based study of an ethnically diverse sample of 11-15 year olds, body composition was measured by bioimpedance (Haroun et al., 2010). Ethnic differences in adiposity did not match the ethnic differences in BMI; White and Black adolescents had significantly higher BMIs than their Asian peers, but the White and Black adolescents had significantly more lean mass and there were no significant ethnic differences in fat mass. The IOTF categories used to classify overweight and obesity are based on BMI. As South Asian children and adolescents have a higher percentage body fat at any given BMI, it was recently debated whether different BMI cut-offs should be used to define obesity in South Asian children in the UK; the conclusion was that the current IOTF definitions ‘remained the most appropriate for use’ as the current evidence is that they do not ‘misclassify children of south Asian ethnicities to a significant extent’ (Viner et al., 2010, p656 & p657). However the authors caution that further research is warranted.

There has been no UK longitudinal study tracking ethnic differences in body size throughout childhood and adolescence. Therefore how ethnic patterns change with age has to be gleaned from several studies which have each focused on specific ages. At birth South Asian and Black babies are lighter than White babies (Moser and Stanfield, 2008).

Conversely from 3 to 5 years Black children in the Millennium Cohort Study were significantly more likely to be overweight than their White peers. In older childhood (9-10 years), the CHASE study found that South Asian children had a significantly higher fat mass index despite having lower BMIs than their White peers (Whincup et al., 2010). DASH showed that higher BMIs are already apparent for the Black Caribbean and African girls at 11 years relative to their White and South Asian peers, and that this difference emerged a couple of years later for the boys. Therefore the picture for the South Asians and Black African and Caribbean children is one of compromised intrauterine growth followed by accelerated growth in infancy and childhood. Such a growth pattern has been linked to obesity and cardiovascular disease in adulthood (Baird et al., 2005, Oken and Gillman, 2003, Singhal et al., 2004). Ethnic differences in growth in early life could therefore be of importance in explaining ethnic differences in obesity and CVD in adulthood (Bhargava et al., 2004, Stettler et al., 2003).

In focusing on ethnic differences it is important not to overlook the high levels of overweight irrespective of ethnicity found in all three studies. Like DASH, HABITS reported high SD scores for waist relative to the 1990 Growth Reference population, particularly for girls (Wardle et al., 2006). The high SD scores for waist, and the other anthropometric measures in early adolescence, likely reflect secular trends over time; the Growth Reference population measurements were taken between 1978 and 1990 (Pan and Cole, 2008) and the DASH pupils were measured in 2002/03 and 2005/06. Previous studies have reported secular changes in height, weight, BMI and waist circumference occurring over a relatively short period of time in children and adolescents in the UK and the US. In correspondence with the DASH and HABITS results, McCarthy et al. (2003) reported that waist circumference increased faster than BMI in adolescents in the UK between 1977 and 1997, particularly in girls, and suggested that BMI was underestimating obesity prevalence. Another UK study reported secular trends in height and weight from 1983-1993; increases were observed in all ethnic groups except for Indian boys (Chinn, 1998). In the US between 1971 and 2002 there were increases in height, weight, and BMI for children at all ages from 2 to 17 years (with the exception of Mexican-Americans at 2-5 years) (Freedman et al., 2006). In a further US study, there were secular increases in height between 1973 and 1992 at all ages from 5 to 13 years, with the increase being greatest for the 9 to 12 year olds and greater for Black children than White children (Freedman et al., 2000). However there was little secular change from the age of 14 years; the authors conclude that the trends in the younger children represent an increase in the rate of maturation (pace of growth), rather than an increase in the final adult height attained. This corresponds with the findings in DASH, where mean heights by 16yrs were generally close to the reference population.

8.2.2 Neighbourhood influences on body size

It is challenging to compare the findings for neighbourhood influences on body size with the existing literature due to differences in samples, setting, and methodology. Nevertheless, this section will attempt to highlight consistencies and inconsistencies.

A positive association between neighbourhood deprivation and adiposity in children and adolescents, regardless of definition of neighbourhood or measure of deprivation, has been reported in recent systematic reviews (Black and Macinko, 2008, Carter and Dubois, 2010). Three subsequent studies confirmed this finding (Fraser and Edwards, 2010, Grow et al., 2010, Potestio et al., 2009) but one found no association (Voorhees et al., 2009). DASH showed a significant association between neighbourhood deprivation and body size for girls but not boys. Compared to girls in the least deprived areas, those who lived or attended school in more deprived areas had significantly larger waists (adjusted for baseline covariates). However there was no trend across the deprivation quintiles. The pattern of association for BMI was similar but not statistically significant. There was no association with waist in the fully adjusted models; this was likely due to the pragmatic decision to code deprivation as a binary variable (most deprived areas [Q5] versus all other areas [Q1-4]) in these models. HABITS showed a similar effect of neighbourhood deprivation on overweight for girls; girls in the most deprived neighbourhoods were the most likely to be overweight or obese, but there was no consistent trend across deprivation categories. The general lack of association in the DASH study may have been due in part to the relatively deprived nature of the sample; the majority of pupils, irrespective of ethnic group, lived in deprived areas and so there may not have been enough variability for a differential effect on body size to be observed.

One of the ways in which neighbourhood deprivation could influence body size is through a lack of opportunity for physical activity due to safety concerns (Black and Macinko, 2008). Walking, cycling, and other forms of activity often take place in public spaces and safety fears can prevent people from using these spaces. However there is often a lack of agreement between crime and fear of crime, and it remains unclear which aspects of crime induce the most fear and are the biggest barriers to activity, how much fear is needed to limit physical activity, whether the most feared places are the most dangerous, or how quickly activity levels change if crime levels change (Loukaitou-Sideris and Eck, 2007). Fear is closely related to the built environment; for example both enclosed spaces with limited exit opportunities (e.g. underpasses), and deserted open spaces (e.g. empty parks) can cause safety concerns. Studies have used a variety of measures to characterise neighbourhood crime levels. Some have used objective measures of reported crimes; others have used measures of physical (e.g. litter, graffiti) or social (e.g. gangs) disorder. Both objective measures of crime and perceptions of safety were considered in this thesis. Increasing neighbourhood deprivation and crime were associated with a decrease in perceptions of safety and area reputation for both boys and girls. However there was a suggestion of gender and ethnic differences in the relationship; girls perceived their neighbourhoods to be less safe at night than the boys, and although the White UK pupils were the most likely to live in less deprived, lower crime, greener areas, they reported least favourably on their neighbourhoods, and were the least likely to report that their neighbourhood was safe during the day. Pupils' perceptions of their neighbourhoods in terms of safety and reputation are likely to reflect how and when they interact with their neighbourhood, their expectations of a good area, and their awareness of how their neighbourhood compares to others. Pupils who had previously lived elsewhere in the UK or in another country may have had different perceptions of safety and reputation than those who had lived in London all their life.

The body size measures were not associated with residential neighbourhood crime levels or perceptions of neighbourhood safety. However higher crime levels in the school neighbourhood were associated with an increase in waist for White UK boys and girls, and Black Caribbean and Nigerian/Ghanaian girls. There is limited literature with which to compare the DASH findings. Only 7 previous studies were identified by a recent review and all had child (<12 years) rather than adolescent samples (Carter and Dubois, 2010). None were based in the UK (5 US, 1 Australian, 1 Canadian). One used objective crime measures, 4 used parental perceptions, 1 used child perceptions, and 1 used both. One study showed an association with body size, but it was only for one age group (10-12yrs) and only for parental perceptions of road safety rather than general safety concerns (Timperio, 2005). Of the 6 studies identified since this review (summarised in Table 1.3), all used perceived measures. Results were mixed both between and within studies (i.e. significant results for one sub-group but not another).

The general lack of association between body size and crime or safety perceptions in DASH may have been due to overall low levels of activity and high levels of sedentary behaviour in the sample regardless of neighbourhood safety. Alternatively, London as a whole has high crime levels relative to many other areas and so there may not have been enough variation in the sample (as even the low crime areas may have been close to high crime areas). A further consideration is that despite the relatively high levels of deprivation and crime in the DASH pupils' neighbourhoods, the vast majority liked the areas in which they lived. Their positive views of their neighbourhoods may have ameliorated any negative perceptions of safety. An additional potential explanation could be that their parents' perceptions of safety would have been more important determinants of time spent in the neighbourhood than the pupils' perceptions.

DASH did not have direct measures of physical activity facilities or food availability but land use was used as a proxy measure of the neighbourhood physical environment. There were clear patterns between neighbourhood deprivation and land use; higher deprivation was associated with a lower proportion of gardens and green space. Green space is associated with lower all cause mortality and self-reported morbidity in the UK (Mitchell et al., 2011). Green space is hypothesised to influence obesity levels through providing spaces and pleasant environments in which to be physically active. In DASH, the proportion of green space in the residential neighbourhoods was not associated with body size, but girls attending schools in greener areas had smaller waists, and to a lesser extent BMIs (adjusted for the baseline covariates). The literature base is small and results are inconsistent; a recent systematic review identified only 13 studies (six of which had a child/adolescent sample), all were cross-sectional and the majority were published recently highlighting that this is a relatively new area of research (Lachowycz and Jones, 2011). Of the studies with child/adolescent samples, two showed a positive association between green space and BMI, three found weak or mixed evidence (e.g. relationships differing by type of green space or sub-groups of the sample) and one showed no association. Lachowycz and Jones' (2011) review also considered the association between green space and physical activity and again found mixed results. Along with green space, private gardens add to the ambient greenery of an area. Results from DASH were inconsistent; boys living in areas with more domestic gardens had lower BMIs. However Black Caribbean and Indian girls in areas with more gardens had higher BMIs.

Greater neighbourhood deprivation was associated with an increase in the proportion of roads and buildings. Neighbourhoods with more roads and non-domestic buildings may have been more walkable if the roads made it easier to get from one place to another and the buildings provided more destinations within walking distance of home. Conversely, if the roads were busy, concerns about traffic safety may have deterred active transport and outdoor play. Furthermore, non-domestic buildings may have included fast food outlets or convenience stores and therefore facilitated access to unhealthy foods. For Black Caribbean boys only, a higher proportion of roads in the residential neighbourhood was associated with an increase in both BMI and waist. Similarly, a higher proportion of roads around a school was associated with a higher BMI for girls. Girls attending schools in areas with the most domestic buildings had higher BMIs, and Indian and Pakistani/Bangladeshi girls living in areas with the most domestic buildings had larger waists. This suggests that for girls, living or attending school in a more suburban area was associated with a larger body size; this pattern was not observed for boys. No previous studies were identified which assessed land use measures equivalent to non-domestic or domestic buildings. However two recent Australian studies (both using the same sample) assessed roads in more detail than in this thesis (e.g. presence of cul-de-sacs, intersection density, access paths, busy roads) (Crawford et al., 2010, Timperio et al., 2010). More paths and intersections were associated with a lower BMI in children (Timperio et al., 2010), however in longitudinal analysis over 5 years of the older children only (10-12yrs at baseline) these factors were not associated with change in BMI (Crawford et al., 2010). Additionally, in a US based study there was no association between street patterns or pedestrian infrastructure and percentage body fat (Dengel et al., 2009). As with crime and safety, it may be that perceptions of walkability and road safety are more important than objective measures but results from recent studies have been mixed and none of the studies were UK based (Table 1.3).

Social norms in an area may influence physical activity and diet, and may influence which resources are present in the neighbourhood. This thesis considered the impact of own ethnic density on body size, with the hypothesis being that higher own ethnic density may promote traditional behaviours and increased access to culturally specific foods; these may have beneficial or adverse effects on body size. Ethnic density and neighbourhood deprivation were related; increasing own ethnic density was associated with less deprivation and crime for the White UK and Indian pupils but greater neighbourhood deprivation and crime for each of the other ethnic groups. Greater own ethnic density was associated with neighbourhoods being perceived more positively by White UK pupils but more negatively by Black Caribbean boys. In an English study, greater ethnic minority concentration for many of the main ethnic minority groups was associated with an increase in the number of fast food outlets, supermarkets, and indoor physical activity facilities per person in the area, but fewer outdoor activity areas (Molaodi et al., 2011b). Therefore high ethnic minority concentration areas have both positive and negative attributes with regards to access to healthy foods and resources for activity.

For the majority of ethnic groups there was no relationship between own ethnic density and body size. Adjusted only for the baseline covariates, greater own ethnic residential neighbourhood density was associated with a decrease in body size for White UK boys, and an increase for Nigerian/Ghanaian girls. The only significant association for the general non-White ethnic density variable was observed for school neighbourhood for other African girls; greater density was associated with a decrease in BMI. The ethnic-specific nature of these results highlights the importance of examining own ethnic density and not just 'non-White' density. There was little association in the fully adjusted models. There was a suggestion (not statistically significant) that high own ethnic density was associated with a higher BMI for Other African boys. There was also a pattern of higher own density being associated with a smaller waist for White UK boys, and a larger waist for Pakistani/Bangladeshi girls, after adjustment for individual and family characteristics and neighbourhood deprivation; however these associations were not significant after further adjustment for school covariates.

Only two previous studies were identified which had examined neighbourhood ethnic density effects on body size in children or adolescents (Grow et al., 2010, Potestio et al., 2009). These US based studies both used broad ethnic density variables ('% non White' and '% visible minority') and neither included individual measures of ethnicity. No associations were found with overweight or obesity after adjustment for neighbourhood deprivation and other covariates. It is important to highlight that the DASH pupils tended to live in ethnically diverse areas, not ethnically segregated areas. This is in contrast to the US where levels of residential ethnic segregation remain high as a consequence of past discriminatory housing policies, which were designed to physically separate White and Black people and to restrict Black people to the least desirable areas (Glaeser and Vigdor, 2001). Williams and Collins (2001) argue that this segregation is 'a fundamental cause of health differences between African Americans and Whites'. African American neighbourhoods tend to be deprived and lack educational and employment opportunities. While there are many poor White people in the US, they are less likely to live in areas of concentrated poverty. In contrast the picture in London is one of ethnic diversity; although some areas have large proportions of ethnic minorities, this does not mean that a given ethnic minority group usually dominates in an area. For example, the London boroughs of Brent and Newham have minority White populations, however in both cases there are more than 15,000 residents of each of five other ethnic groups living there (Finney and Simpson, 2009).

Overall, this thesis found very little of the variation in body size was due to differences between neighbourhoods, and there were few significant associations between neighbourhood characteristics and body size. This does not mean that there are not neighbourhood effects on body size; rather the measures used in this thesis may have failed to capture relevant features. In support of this, a recent London based qualitative study found that parents and their children (8-13yrs) thought that the areas they lived in influenced diet and physical activity (Rawlins et al., 2011). Parents were concerned about the abundance of shops selling ‘junk food’ near their home and their child’s school. The food outlets often accommodated ethnic preferences (e.g. Halal meats) and the food was cheap and therefore affordable for the children. Parents felt that this undermined their efforts to ensure their child had a healthy diet; for example one of the Black Caribbean mothers is quoted as saying “…it’s not easy because there are so many fast food shops and most of them are selling their food for one pound…”. With regards to physical activity, both parents and children in this study mentioned concerns about safety in parks. These included dangers posed by strangers, gangs, dogs, and violence. One Black African 11 year old mentioned that if you went in her local park “…you can just get shot…” (Rawlins et al., 2011). Parents, particularly those of higher SES, mentioned that they did not allow their children to play outside or ride their bikes without supervision, or to walk home alone, due to road safety worries.

8.2.3 School influences on body size

The DASH pupils attended ethnically diverse schools, with ethnic clustering being greater in schools than in neighbourhoods for the ethnic minority groups. In contrast to neighbourhoods, where greater ethnic minority density was generally associated with greater neighbourhood deprivation and crime, many of the schools with high concentrations of ethnic minority pupils were relatively high achieving. This was particularly the case for the all-girls, religious schools which had high proportions of Nigerian/Ghanaian girls. Therefore groups exposed to high levels of neighbourhood deprivation were not necessarily exposed to a poor school environment.

DASH showed very little of the variance in BMI or waist to be due to differences between schools (<1% for boys and <3.5% for girl). A US based study of 17,000 adolescents in

132 schools also found the proportion of variance at the school level for BMI to be small but slightly higher than in DASH; 3.5% for boys and 4.8% for girls (Richmond and Subramanian, 2008). Similarly, a further large US study of over 40,000 adolescents found 3% of the variance in BMI to be at the school level (this study used self reported height and weight) (O'Malley et al., 2007).

As with neighbourhood ethnic density, school ethnic density was not consistently related to body size across the ethnic groups. Adjusted for the baseline covariates, greater own ethnic density was associated with a decrease in both BMI and waist for Pakistani/Bangladeshi boys, and waist for White UK boys. A similar pattern was observed for White UK girls but was not statistically significant. In contrast, greater own ethnic density was associated with an increase in BMI and waist for Other African girls. In the fully adjusted models, high own ethnic density was associated with a smaller waist for Indian and Pakistani/Bangladeshi boys, and Black Caribbean girls. In contrast, for Pakistani/Bangladeshi girls it was associated with an increase in BMI. Only two other studies examined school ethnic density on body size. In the US-based Richmond (2008) study, school ethnic density (binary variable: ≤66% White or >66% White) was not associated with BMI for girls or boys. In contrast to the DASH pupils, the pupils attended ethnically segregated schools; almost 40% of the White pupils attended a school where >94% of the pupils were White. A further US study showed an association with ethnic density for Black and Hispanic girls; those in mainly White schools (>50% White) had lower BMIs than their peers who attended mainly non-White schools (Bernell et al., 2009). A strength of the study is that a wide range of potential confounders were adjusted for, including family income, parental BMI, breakfast eating, TV watching, sports participation, and neighbourhood ethnic density.

No clear relationship between school level SES (measured by academic performance, unauthorised absence, and proportion receiving free school meals) and body size was found in this thesis. In the fully adjusted models, compared to boys in the highest academically performing schools, those in lower schools had significantly higher BMIs but this was not observed for waist. Compared to girls attending schools with low unauthorised absence, those in schools with higher absence rates had significantly larger waists but this relationship was not found for BMI. With regards to unauthorised absence, it is important to consider reverse causation as overweight children may be absent from school more often than normal weight children (Geier et al., 2007). The proportion receiving free school meals was unrelated to body size. In the Richmond (2008) study, lower school SES (school level median household income) was associated with higher BMI for both boys and girls. O'Malley et al. (2007) also found school level SES (parental education aggregated to school level) to be inversely associated with BMI even after adjustment for individual SES.

School type was a significant correlate for girls in DASH; those attending Catholic schools had higher BMIs than those in non-denominational schools. The Nigerian/Ghanaian girls were the most likely to attend a Catholic school (with over half of them doing so) and proportions were also relatively high for the Black Caribbeans and Other Africans. Therefore it is difficult to disentangle whether the higher mean BMI of the Catholic schools is due to a school effect or a selection effect (i.e. girls from these ethnic groups who attend Catholic schools may differ from their peers who attend non-denominational schools). Other studies assessing school type have considered public versus private schools and so are not directly comparable to DASH (which did not include any private schools). O'Malley et al. (2007) reported that those in public schools had a higher mean BMI than those in private schools but this association was entirely explained by adjustment for school SES. A further US study also found that pupils in public schools had a higher mean BMI than those in private schools and that this difference by school type was larger for children from low SES families (Li and Hooker, 2010).

There was no relationship between the school ethos measures and body size in DASH. The pupils were generally positive about their teachers, but associations with body size were mixed. Adjusted only for the baseline covariates, boys who disliked their teachers had a significantly lower BMI and waist than those who liked them. This relationship was not observed for girls. Not having an encouraging teacher was associated with a significantly lower BMI for White UK girls but a significantly higher BMI and waist for Other African and Indian girls. Girls who attended a school where a large proportion of pupils did not like their teachers had a higher BMI than those in schools where a high proportion liked their teachers. No previous study was identified which had compared measures of ethos or perceptions of school with body size. However studies have found a more caring school ethos to be associated with healthier behaviours. An Australian study found that children who viewed their teachers as being unsupportive were significantly more likely to regularly eat fast food than those who thought their teachers were highly supportive (McLellan et al., 1999). However no relationship was found for physical activity, and perceptions of the school environment were not associated with fast food or activity. Other studies have found that schools with a positive ethos, a holistic approach (as opposed to being focused only on academic achievement), with pupils engaged with education, and with good relationships between pupils and teachers, have reduced pupil drug use, smoking and drinking (Fletcher et al., 2008, Gordon and Turner, 2003, Henderson et al., 2008, Nutbeam et al., 1993, West et al., 2004).

8.2.4 Individual and family influences on body size

The focus of this thesis was on contextual factors, but the significant results were mainly at the individual and family level. Findings generally consistent with the existing literature were identified for pubertal status, maternal overweight, maternal smoking, and skipping breakfast.

Pubertal status was a key correlate of body size. The gender difference in the timing of the emergence of ethnic differences in BMI could reflect differences in pubertal timing, as the girls were generally more likely to be in late puberty than the boys. Within gender, there were ethnic differences in pubertal status and these differences explained some of the ethnic difference in body size. The Black Caribbean boys and girls, and the Nigerian/Ghanaian and Other African girls, were significantly more likely to be in late puberty in early adolescence than their White UK peers. This is similar to the findings of several US based studies which have consistently found African American girls to have a lower menarcheal age than White girls (Styne, 2004). The earlier puberty of the Black Caribbean and Black African girls may reflect them having larger body sizes in childhood, but studies have found that BMI alone does not fully account for differences in pubertal timing and genetic and environmental factors also play a role (Kaplowitz et al., 2001). In boys this BMI-puberty relationship has not been observed. A US study found early maturing boys to be thinner than those who matured later (Wang, 2002).

Maternal overweight had previously been shown to be associated with overweight and obesity at 11-13yrs in the DASH pupils (Harding et al., 2008b). This thesis extended this work by confirming the association in the longitudinal sample for the continuous measures of body size; pupils who reported having an overweight mother had significantly higher BMIs and larger waists than those who did not, with the effect sizes being slightly larger for waist than BMI. These associations did not differ by ethnic group, and there was also little ethnic difference in the proportion of pupils with an overweight mother. Several previous studies have found a positive association between maternal BMI and their offspring's body size in childhood, adolescence, and adulthood (Danielzik et al., 2004, Gibson et al., 2007, Koupil and Toivanen, 2008, Kowaleski-Jones et al., 2010, Laitinen et al., 2001, Olvera et al., 2007, Strauss and Knight, 1999, Whitaker, 2004, Whitaker et al., 1997). All had objective measures of height and weight, an advantage over the subjective pupil-reported measure in DASH. Similar to DASH, maternal body size was associated with both daughters' and sons' body size in these studies, with the exception of Olvera et al. (2007) who found the relationship for daughters only. A four category maternal BMI variable (low, normal, overweight, obese) allowed a dose-response relationship to be demonstrated in one of the studies: children (0 to 8yrs) of low BMI mothers were significantly less likely to be obese than those with normal BMI mothers; those with overweight mothers were significantly more likely to be obese than those with normal weight mothers; and those with obese mothers were significantly more likely to be obese than those with overweight mothers (Strauss and Knight, 1999). One study found average maternal BMI over the child's life to have a stronger relationship to child's BMI than a single measure of maternal BMI (Kowaleski-Jones et al., 2010).

Two of the studies also included fathers' weight status (Danielzik et al., 2004, Whitaker et al., 1997). Danielzik found both maternal and paternal obesity to be associated with overweight and obesity in 5 to 7 year old children. Whittaker did not distinguish which parent was obese but reported that those who had one or two obese parents when they were children were more likely to be obese as young adults (21-29 years old) than those who did not, with the risk generally being higher for those with two obese parents than those with one. In contrast, in DASH pupils who reported their father was overweight did not have significantly higher BMIs or larger waists than those who did not. The reason for this discrepancy is unclear.

The correlation between parental and child body size probably reflects both shared genetics and environment. Parents shape their children's eating and activity environment (Whitaker, 2004). Food preferences develop early in life and result from repeated exposures to foods (Cashdan, 1994, Golan and Crow, 2004). Parents are often the gatekeeper to what food enters the home and how it is prepared and they can model a healthy or unhealthy diet for their children. A review concluded that 'children's food related knowledge, preferences, and consumption are related to parents' preferences, beliefs and attitudes towards food' (Patrick and Nicklas, 2005). Some studies have shown child fruit and vegetable intake to be correlated with parents' intake (Gibson et al., 1998, Orlet Fisher et al., 2002). However a recent systematic review found generally weak correlations between parents and their children for fat and energy intake, however the evidence base was limited; only 24 studies were identified and sample sizes were often small (Wang et al., 2011). Parents may also be role models for physical activity behaviours; a systematic review concluded that father's physical levels correlated with their child's in the majority of studies but that this association was generally not observed for mothers (Ferreira et al., 2006). With regards to maternal obesity, associations with child body size may also be mediated via the intrauterine environment; maternal obesity may result in changes in foetal growth and energy metabolism in the developing foetus (Oken and Gillman, 2003, Whitaker and Dietz, 1998).

Maternal smoking rates were highest for the White UK pupils, and were generally above 20% for the Black Caribbeans. Rates were very low in the other ethnic groups. Girls who reported that their mother smoked had significantly larger waists and higher BMIs than those who did not. This relationship with BMI and waist was not observed for boys, but boys with smoking mothers had more than twice the odds of being overweight/obese, with this relationship being borderline significant. A potential mechanism is via the effects of maternal smoking during pregnancy. A recent meta-analysis found that children of mothers who smoked during pregnancy were at increased risk of being overweight from 3 to 33 years independent of factors such as SES, gestational weight gain, parental body size, birth weight, or infant feeding (Oken et al., 2007). However body composition was not considered. A recent study did not find an association between maternal smoking during pregnancy and subcutaneous fat mass in children from birth to two years (Durmus et al., 2011). The biological pathway through which smoking in pregnancy affects overweight levels in offspring is still unclear but it may cause changes to body composition and appetite behaviour (Oken et al., 2007).

Many pupils skipped breakfast; over 50% for Nigerian/Ghanaian and Other African boys and girls, and Black Caribbean girls. In common with other studies, the girls were more likely to skip breakfast than the boys (Rampersaud et al., 2005). With the exception of Indian boys and girls, and Pakistani/Bangladeshi boys, the ethnic minority groups were more likely to skip breakfast than their White UK peers. Compared to those who ate breakfast everyday, the DASH pupils who skipped breakfast in early adolescence had higher BMIs, larger waists, and were more likely to be overweight or obese, in both early and late adolescence. In a review of breakfast eating in children and adolescents most, but not all, studies found an association between skipping breakfast and greater body size (Rampersaud et al., 2005). Many studies found breakfast skipping to increase with age in children and adolescents but as DASH only included this measure at Wave 1 it is unknown if that was true in this study. The authors of the review were unclear on the mechanism behind this association; all but one of the studies was cross-sectional meaning it was not possible to determine the direction of association. In the longitudinal study which studied 9 to 14 year olds over 3 years, the relationship between breakfast eating and weight trends differed by weight status. There was a suggestion (not statistically significant) that in normal weight children, those who never ate breakfast gained more weight than those who ate it everyday. In contrast, for overweight children those who skipped breakfast had a smaller increase in BMI than those who ate breakfast (Berkey et al., 2003). Studies have reported that breakfast skippers consume less calories than those who eat breakfast but this could reflect reporting bias; those who are overweight could be more likely to both skip breakfast and to under-report energy intake (Rampersaud et al., 2005). It is thought that those skipping breakfast may have lower physical activity levels and may consume a higher percentage of their energy intake from fat than those who eat breakfast (Rampersaud et al., 2005).

The other dietary measure included in this thesis was fruit and vegetable intake. Overall, only around a third of the pupils were eating the recommended 5+ portions per day. The White UK and Indian pupils were the most likely to report doing so. The high fibre and water content of fruit and vegetables is thought to promote satiety and reduce hunger; consumption could therefore protect against obesity if they displace energy dense foods in the diet (Rolls et al., 2004). However in this thesis, girls who ate less than one portion per day actually had lower BMIs than those eating five or more, and no association with body size was observed for boys. These results are not inconsistent with the existing literature; in a review of the small number of longitudinal studies of fruit and vegetable intake and adiposity in children, only half found the expected inverse relationship (Ledoux et al., 2011).

Activity levels overall were low, with girls reporting less activity than boys and levels declining in both genders with age. It is unlikely that many of the pupils were meeting the current recommendation for 5 to 18 year olds of one hour of physical activity per day (which should be a mixture of moderate and vigorous intensity) and muscle strengthening activities on three days per week (NHS, 2011). There is no required minimum time for physical activity in the school curriculum in England. The 'PE and Sport Strategy for Young People' was set up in 2003 with the aim of increasing the numbers of young people who participate in high quality PE and sport (Quick et al., 2010). The Government target of 85% of children having '2 hours of high-quality physical education and school sport a week' was reached in 2007 (Association for Physical Education Health, 2008, p4). The new goal is for 2 hours of curriculum PE plus 3 hours of extra curricular sport per week. The latest national PE and Sport Survey (2009/10) reports the proportion of pupils doing at least 3 hours of high quality PE and out of hours school sport on an average week (Quick et al., 2010). Similar to the DASH findings, the proportions declined with age (from 59% in Year 7 to 21% in Year 13). Furthermore, in every Year group boys were more likely to do 3 hours PE and sports than the girls (ranging from 61% and 56% respectively in Year 7 to 28% and 15% in Year 13). Schools were less likely to meet the targets if they: had a high proportion of pupils receiving free school meals, were located in a deprived neighbourhood, had a high proportions of ethnic minority pupils, or had a high proportion of pupils with special educational needs. Furthermore all-girls schools were less likely to meet the target than mixed or all-boys schools.

In this thesis family level disadvantage was not associated with greater body size. The most deprived boys (as measured by the standard of living items) actually had significantly lower BMIs and smaller waists than the least deprived. As in this thesis, RELACHS also considered a range of family level SES measures (car ownership, parental employment, crowded home, and receiving free school meals) and had a relatively deprived sample overall. As with DASH, disadvantage was not associated with an increase in overweight and obesity, and there were some instances where more deprivation was associated with lower risk (e.g. boys with neither parent in work had a lower risk of overweight than those with a working parent) (Taylor et al., 2005). These findings from DASH and HABITS contradict those from a multi-national study of the relationship between socio-economic position and overweight among adolescents (Due et al., 2009). The prevalence of overweight (calculated from self-reported height and weight measures) was found to be higher in those from more deprived families in 21 out of 24 Western countries in the study. However the size of the SES difference (low versus high) differed by country and by gender, and was low for England relative to most other countries; overweight prevalence was 2.8% higher in low SES boys compared to high SES boys, and the equivalent figure for girls was 4.7%. By way of comparison the equivalent figures for the US were 11.5% and 10.2%.

Generational status and the measures of acculturation were considered as correlates of body size but no association was found. Dietary habits often change after migration, and young people may be particularly likely to change to a more Western diet (Gilbert and Khokhar, 2008). This often means eating more unhealthy foods and less of the fruits, vegetables, and grains that comprise a more traditional diet. Perceptions of body size may also differ between cultures, with obesity generally being viewed negatively in Western countries but more positively in some other countries (Gardner et al., 2010). We viewed those who had friends the same ethnicity as themselves, who spoke languages other than English at home, and who regularly attended a place of worship, as being more exposed to the traditional cultures and norms of their own ethnic group. These behaviours were common in many of the ethnic groups, signalling that the pupils were straddling cultures. Pupils in all ethnic groups may have been exposed to a variety of cultures in their schools and neighbourhoods and these may have differed from their family's cultural background.

The association between sleep duration and body size was also considered in this thesis but in contrast to many previous studies no significant association was found. Energy expenditure during sleep is lower than when awake. Therefore the association between short sleep duration and greater likelihood of obesity in children and adolescents reported in several systematic reviews is counterintuitive (Chen et al., 2008, Must and Parisi, 2009, Nielsen et al., 2011). Possible mechanisms include short sleep inducing hormonal changes which increase appetite, or tiredness resulting in a more sedentary lifestyle (Must and Parisi, 2009). However Horne (2011) is sceptical of the relationship between length of sleep and obesity being causal, and states that any relationship is likely due to confounding factors. He states that the small amount of weight gain associated with shorter sleep could be rectified by a relatively short amount of exercise whereas there is no evidence that extending sleep would be an effective intervention.

Pupil smoking status was considered as a correlate of body size but was found to be unrelated. Previous studies have found mixed results for the association. Smokers generally have lower weights than non-smokers, with a review concluding that this was likely due to nicotine increasing the metabolic rate; evidence for nicotine reducing calorie consumption through appetite suppression is less strong (Chiolero et al., 2008). But the relationship is complicated as smoking often clusters with risk factors for obesity such as poor diet, lack of physical activity, higher alcohol intake, and low SES. This is a potential explanation for why heavier smokers tend to gain more weight over time, and are more likely to be obese, than light smokers (Chiolero et al., 2008). Smoking may also affect fat distribution via hormonal changes which encourage the accumulation of visceral fat (Chiolero et al., 2008). Many young people, particularly girls, believe that smoking aids weight control and girls who are overweight, or believe they are overweight, may be more likely to start smoking (Cawley et al., 2004). Therefore at a young age, smokers may be heavier than non-smokers.

8.2.5 Gender differences

All analyses were stratified by gender as previous work on Wave 1 of the DASH study had revealed gender differences in the ethnic patterning of overweight and obesity (Harding et al., 2008b). It was also anticipated that boys and girls may interact with their contexts differently and hence contextual influences on body size may differ by gender. As discussed in Section 8.2.4, differences between girls and boys in the average age of puberty likely contribute to the gender differences in the emergence of ethnic differences in BMI. Gender differences within ethnic group, as was seen for the Other Africans, are harder to explain. Other African is a broad category, which unfortunately could not be disaggregated further, and it is possible that the ethnic composition of this group differed between boys and girls. Alternatively, there may be gender differences in the exposure of Other African girls and boys to cultural norms and traditions and the ways in which they socialise and interact with their environments.

There were some gender differences in obesogenic behaviours. Physical activity levels were lower in girls than boys but both reported similar levels of sedentary behaviour. It is important to emphasise that there were gender differences in the specific physical activities and sedentary behaviours reported. This has implications for comparing associations with body size between genders, and highlights a limitation in using such broad proxy measures of energy expenditure. It is also an important consideration from a policy perspective as interventions may be more effective if focused on activities more relevant to boys and girls. There was little difference between boys and girls in fruit and vegetable consumption, but girls were considerably more likely to skip breakfast than boys. Potential differences between the genders in their reasons for skipping breakfast are an important consideration from an intervention perspective.

With regards to the contextual measures, there was little difference between the girls and boys in the objective characteristics of their residential neighbourhoods. However the girls were generally less likely to report that their neighbourhood was safe. This emphasises that there could have been gender differences in the ways the pupils interacted with their surroundings, and that perceptions may be more important than objective measures in detecting gender differences. In contrast to the lack of gender difference in objective neighbourhood measures, on average the girls attended better performing schools than the boys. This was a consequence of the all-girls schools performing better than mixed schools on a range of measures, and all-boys schools often performing worse. It is difficult to know to what extent these differences by school type are representative or whether they are due to sampling.

8.3 Strengths

Most studies of contextual influences on body size in children and adolescents have considered only characteristics of residential neighbourhoods; a strength of this thesis was the additional inclusion of school and school neighbourhood characteristics as these additional contexts also play a prominent role in the lives of young people. A further strength was the use of longitudinal data which allowed examination of how ethnic differences in body size, and differences in individual and family behaviours, change with increasing age in adolescence. How the neighbourhood and school environments changed was also considered.

The DASH study was specifically designed to investigate ethnic differences in young people's health and the sampling frame ensured good representation of each of the main ethnic groups in the UK. This allowed detailed examination of body size and its relationship with body size by gender and ethnicity. This was important as boys and girls may interact with their environments differently, and the use of ethnic categories such as 'White', 'Black' and 'Asian' aggregates groups with diverse historical backgrounds and cultures. The importance of moving beyond such broad categories has been emphasised (Agyemang et al., 2005), and the findings in this thesis highlight the benefits of being able to do so. For example, the Indians were generally less deprived (as measured by individual, neighbourhood and school deprivation) than the Pakistani/Bangladeshis, and the Nigerian/Ghanaians were generally less deprived than the Other Africans. Some of the differences in BMI and waist trends would have been missed had aggregate categories been used, for example between the Nigerian/Ghanaian and Other African boys. Furthermore this study was able to determine gender differences in body size and contextual influences within ethnic group; for example the Other African girls, but not the Other African boys, had higher BMIs than their White peers, and among the Nigerian/Ghanaians, the girls attended better schools than the boys.

The majority of studies on neighbourhood effects on body size have used overweight or obesity as outcomes. Instead, this thesis focused on continuous measures of body size as the health risks associated with a higher BMI increase linearly and appropriate BMI cut-offs may differ by ethnic group (Willett et al., 1999). As body composition and fat distribution differ by ethnic group, this thesis included two measures of body size, BMI and waist circumference, as has been recommended for studies investigating ethnic differences (Scarborough et al., 2010).

This study benefited from including a range of areas and schools. The DASH sample lived in neighbourhoods in north, south, east and west London. The 49 schools were located across ten boroughs and varied widely in terms of school type, academic performance levels, ethnic density, and the socio-economic circumstances of the pupils. Many previous studies have included either objective or subjective contextual measures; in contrast this thesis included both which allowed an examination of how they were related and if either were potentially important determinants of body size. The contextual characteristics were time-varying covariates where possible; therefore in this thesis it is explicitly acknowledged that the school and neighbourhood environments could change over time.

8.4 Limitations

This study has several limitations which must be considered when interpreting the results. Limitations of the sample and of the data (neighbourhood, school, and individual and family) are discussed.

8.4.1 The DASH sample

In light of the findings in this thesis, we arguably ‘missed the boat’ with the DASH sample in terms of detecting important drivers of body size and ethnic differences in body size; in early adolescence the pupils as a whole already had high BMIs and large waists relative to the reference population, and ethnic differences were already apparent at this age for girls and emerged soon after for boys.

All of the pupils lived and attended school in London which constrained the variability in the contextual exposures. Furthermore the London location limits the generalisability of results. The experiences of White and ethnic minority adolescents living in less ethnically diverse, less urban, less deprived, or lower crime parts of the UK may be very different. London has an extensive public transport network and compared to those living in more rural areas, or even smaller towns and cities, adolescents in London may be able to access resources further from home more easily. Due to the high population density of London there are likely to be more resources closer to home (e.g. shops, fast food outlets) than in less populated areas. An additional consideration is that obesity levels in London are generally lower in adults than those in many other areas of England, although this pattern is not observed for children (NHS, 2008).

The schools which participated in DASH may not be representative of London schools in general. The Nigerian/Ghanaian girls in this thesis were clustered in the high performing schools; this may not be representative of the experiences of most Nigerian/Ghanaian girls in the city.

8.4.2 Defining and characterising neighbourhoods

Key considerations in the study of contextual influences on health are how to define a given context, the identification of characteristics relevant to a given outcome, and the availability of valid measures of those characteristics. Neighbourhoods do not have clear boundaries and can be difficult to define. For the objective measures, this thesis used the conventional approach of defining a neighbourhood using geographical units with non-overlapping, fixed boundaries (Cummins et al., 2007, Galster, 2001). These geographical units (LSOAs) have the advantage of being similar to each other in population size and having constant borders over time, plus neighbourhood data are readily available at this level. However they may not correspond to what pupils perceived their neighbourhood or the neighbourhood of their school to be (Flowerdew et al., 2008). The assumption is that individuals living in the same LSOA, but perhaps some distance from one another, are exposed to a more similar environment to each other than they are to someone who may live across the street but who is in a different LSOA (Reardon and O'Sullivan, 2004); there are obvious limitations with this approach. Neighbourhoods in reality are not discrete spaces that can be easily defined, and people are not influenced by a single bounded space; boundaries are often fluid and people are exposed to multiple contexts (Cummins et al., 2007). The DASH pupils may have spent their time in a different LSOA to the one in which their home was located. The characteristics of the wider area surrounding each of the LSOAs in which they lived and attended school were not considered and this could have been important in determining what resources the pupils had close to their homes (e.g. it was not possible to distinguish between a deprived LSOA that was bordered by other deprived areas and a deprived LSOA surrounded by relatively affluent ones).

Related to this point, the LSOA could have been too small a scale, particularly in later adolescence when the pupils may have had more independence and been able to travel further from home (on average a London LSOA is 0.34km^2). It is likely that the most appropriate scale could have differed by characteristic but in this thesis the same spatial scale was used to measure all of the neighbourhood characteristics (Galster, 2001). For the subjective measures, residential neighbourhood was defined as 'the area where you live'. Unfortunately the DASH questionnaires did not include items on how much time the pupils spent in the neighbourhood near their home or their school, or what neighbourhood resources they used or did not use and the reasons for this, or the extent their parents or school mediated exposure to the neighbourhood environments.

In common with most studies of neighbourhood effects, it was not possible to rule out self-selection (or, because of the young age of this sample, parental selection). For example, do active people choose to live near green space or does living near green space makes people more active. Similarly, it was not known to what extent selection was operating for the schools. The clustering of some groups (e.g. the Nigerian/Ghanaian girls) in single-sex, religious schools suggests that some parents were selecting particular types of schools for their children. The greater ethnic clustering of ethnic minority pupils in schools than in neighbourhoods could be the result of selection (i.e. parents choosing to send their children to a school with a higher proportion of own ethnic density pupils), or it could be that the ethnic composition of the schools reflects the ethnic composition of young people in the school's area [as residential ethnic density was based on 2001 census data of all residents in a neighbourhood (i.e. people of all ages), whereas school ethnic density was based on the school censuses of secondary school age children (i.e. 11-18yrs approximately)].

There were also limitations to the measures used to characterise the neighbourhoods. Neighbourhood deprivation was measured by the Index of Multiple Deprivation (IMD). This is comprised of seven domains, one of which is crime, and crime in turn is comprised of burglary, theft, criminal damage, and violence. The multi-dimensional nature of the deprivation and crime measures may not have been able to capture associations with body size. For example, violence may have been more important than burglary in deterring physical activity.

Ethnic density was defined as the proportion each ethnic group comprised in the neighbourhood or school. Quartiles of own ethnic density were derived; the cut-offs for these quartiles differed by ethnic group. Therefore it is not possible to directly compare the impact of being in, for example, the highest own ethnic density quartile across groups. A limitation of these own ethnic group quartiles was that they give no information on which other ethnic groups were in the neighbourhoods or schools. Rather than ethnic density, other measures of ethnic segregation or isolation may have been more important. The density measure used in this thesis does not take into consideration how ethnic groups are integrated or segregated *within* a neighbourhood. For example, two neighbourhoods with the same proportion of a given ethnic group could differ substantially in how individuals from that group were distributed in the area. Reardon and O'Sullivan (2004) propose that the distribution of individuals in a given group in a neighbourhood can be thought of in terms of two dimensions: 'exposure/isolation' (the extent to which members of one group encounter members of another group in the same area) and 'evenness/clustering' (the extent to which individuals of the same group are clustered near others of the same group in the area). Groups in an area can therefore be described as having one of four distribution patterns: even and isolated; even and exposed; isolated and clustered; and exposed and clustered. There is extensive literature on other methods of measuring segregation (not just ethnic segregation), many of them complex, but the debate as to the advantages of the various measures continues (e.g. Harris, 2011).

The land use types were defined as the percentage of each land type in each neighbourhood. The literature review in Chapter 1 emphasised the importance of both the presence and accessibility of facilities in potentially influencing health and health behaviours. However the land use types used in this thesis were broad categories which lacked this information. However despite the crude measures used, clear associations between neighbourhood deprivation and land use were observed and it was possible to distinguish between neighbourhoods which appeared to be more suburban and those which were more built-up. Nevertheless, the land use data were not able to inform which resources were actually present in an area e.g. what businesses or buildings comprised the non-domestic land use or whether roads were busy arterial roads or quiet suburban avenues. With the green space data it was not possible to know if the area was accessible, if it was somewhere young people could be active, or if there were any facilities present or the condition of them. A study which assessed different green space measures found that those which only included large green spaces underestimated green space, particularly in the most deprived areas, relative to more detailed measures which captured all ambient greenery. However in terms of association with mortality and self-reported morbidity results were similar for both measures, which suggested that larger green spaces were more important for health and that there was no advantage in using more detailed green space measures in analysis (Mitchell et al., 2011). The use of quartiles of land use based on simple percentage measures may not have been the best measure to capture associations with body size; distance from home may have been more important (e.g. green space or non-domestic buildings within walking distance). However this type of measure is also not straightforward as what is actually within walking distance and what residents perceive to be within walking distance can differ (Macintyre et al., 2008).

An important limitation is that there were no data on length of exposure to the neighbourhood environments; there was no way of distinguishing between pupils who had lived in an area for several years and those who had moved there recently. Given that the accumulation of body fat takes time, it would be expected that exposure to an obesogenic environment would have had a larger impact on someone who had been exposed to it for longer.

8.4.3 Defining and characterising schools

In contrast to neighbourhoods, schools are easily defined, discrete spaces. The length of exposure to the school environment was also easier to estimate. At Wave 1 many of the pupils were only in their first few months of their secondary school, arguably too short a time to have had much of an impact on body size. Therefore characteristics of the primary school environment may have been more important at this age.

The proportion of pupils receiving free school meals in each school was the most direct measure of pupil SES used in this thesis. The main limitation of this measure is that not all pupils eligible for free school meals receive them, meaning that the number of pupils from low income families can be underestimated. Furthermore it only gives an indication of the proportion of pupils from the lowest income families, and gives no sense of the distribution of SES in the rest of the pupils. Given the limitations, two additional proxy measures (unauthorised absence and academic performance) were also considered.

A major limitation of the ethos measures was that they were only available at Wave 2 and there was considerable missing data. It is therefore acknowledged that these measures may have failed to capture the true exposures of the pupils, particularly in early adolescence.

8.4.4 Measuring individual and family characteristics

The individual and family variables were self-reported by the pupils and hence their validity was dependent on how accurately pupils were able to complete the questionnaires. Given that change over time was of central interest to this thesis, it was a limitation that some variables were only included at one Wave, for example skipping breakfast and subjective opinions of teachers were only included at Wave 1; physical activity time, breathless activity, sedentary time, active commuting, and sleep were only included at Wave 2. The inclusion of variables only present at Wave 2 in the longitudinal models raises the issue of reverse causality. Some variables were measured in different ways at each Wave, a key example being two of the physical activity variables ‘number of activities’ and ‘number of activity sessions’. At Wave 1 the pupils reported on an average week, whereas at Wave 2 they were asked about the previous 7 days. A further consideration is that the questionnaire at Wave 1 asked about physical activities out of school only, whereas Wave 2 included activities both in and out of school. Therefore the drop in activity levels seen with increasing age could be larger in reality than was reported (if it is assumed that the pupils would have reported more activity at 11-13yrs if the questionnaire had included in school activities). At Wave 1 the number of sessions was coded as 7 for every day, 4 for most days etc. However this could have underestimated the number of sessions and again could have resulted in the real drop in activity with increasing age being under-estimated in this study. Another issue is that all activities were counted equally. From an energy expenditure point of view, this is a definite limitation. However as there was no information on how much energy the pupils expended doing any of the activities it was decided that it would not make sense to attempt to group them into expenditure categories (e.g. vigorous exercise). The total breathless time is likely to be an over-estimation as it assumes that pupils were breathless for the entire time they did an activity.

The sedentary question only asked about the previous day; it therefore may not have been a good indicator of a pupil’s typical sedentary patterns. Similar to the physical activity measure, it was assumed that all sedentary behaviours were equal. However the type of sedentary activity could be important as some are more likely to be associated with unhealthy habits. For example the association between television viewing and snacking on energy dense foods has been well reported (for example Cleland et al., 2008, Francis et al., 2003, Salmon et al., 2006). Conversely, a systematic review of studies concluded that playing ‘active’ computer games (those that require physical activity beyond that of conventional hand-controlled games) was equivalent to light to moderate activity in children and adolescents (Biddiss and Irwin, 2010).

The active commute variable could have underestimated the number of pupils who walked to or from school. Given that the average commuting time for those who walked to school was a little over a quarter of an hour, those who used public transport may actually have walked for more than that as part of their commute.

Neighbourhoods and schools are hypothesised to influence body size through influences on physical activity and diet. It was not possible with the DASH data to examine contextual influences on these energy balance components as the questionnaires did not include dietary or activity measures which were detailed enough to calculate energy consumed or expended.

8.4.5 Sample size, attrition, and missing data

It is important to consider whether the DASH sample was adequate for examining neighbourhood and school effects. Neighbourhood clustering was low in DASH (i.e. few individuals per neighbourhood) which is a common issue in studies of neighbourhood effects and is a consequence of neighbourhoods often not being the sampling frame (Clarke, 2008). An additional concern for longitudinal cohort studies of neighbourhood effects is that clustering reduces over time due to attrition and residential mobility (Clarke, 2008). It is therefore important to consider the minimum sample size and degree of clustering needed in order for MLM to produce valid results, and the consequence of using analytical methods that ignore clustering when the level of clustering is low.

Studies with a clustered design need a larger sample size than those without clustered data to have the same amount of statistical power. When considering sample size in multilevel models it is important to consider the sample size at each level of the model (i.e. the total number of units at each level) (Snijders, 2005). The sample size at the upper level is usually of greatest concern as group-level cluster size will always be smaller than individual-level sample size (Maas and Hox, 2005). It is known that the number of clusters is more important than the number of individuals per cluster for unbiased and efficient estimates using MLM (Clarke, 2008). However less is known about the minimum sample size and degree of clustering needed in order for MLM to produce valid results.

The 30/30 rule (at least 30 groups with at least 30 individuals per group) was first proposed by Kreft in 1996; two years later Hox suggested the 50/20 rule (50 groups with 20 individuals per group) as a minimum sample for the analysis of cross-level interactions (Bell et al., 2008, Hox, 1998). As discussed above, these minimum sample size recommendations are rarely met in epidemiological studies of neighbourhood effects. Therefore a number of recent methodological studies have used simulated datasets in order to determine if MLM is a valid technique when data are sparse. In a recent study which explored the impact of very small group sizes (n=1 to 5), neither fixed nor random estimates were affected as long as the number of clusters was large (n=459) (Theall et al., 2011). This finding held at the extremes of data sparseness (90% of clusters with only one observation), and when individual, group, and aggregated group level covariates were added to the model. However if the number of clusters was low (n<50) the standard errors of both fixed and random effects increased, as did variance at the upper level – hence raising the ICC. Similarly, Bell et al. (2008) found that the proportion of neighbourhoods with single observations had little impact on fixed effects or estimates of variance when the number of clusters was large (n=500); with a lower number of clusters (n=50) the accuracy of upper level estimates was reduced but there was no impact on the level-1 fixed effect estimates. The results of these studies, plus others with similar findings (e.g. Hox, 1998, Maas and Hox, 2005, Snijders, 2005), suggest that MLM techniques are statistically appropriate for studies like DASH which have sparse data but many clusters. However, although statistically robust, it is debatable whether they are able to inform adequately on the importance of neighbourhood effects, as it is difficult to disentangle individual from neighbourhood characteristics when many neighbourhoods have only one individual.

In this thesis neighbourhood was not included as a level in the models and neighbourhood characteristics were included as individual-level covariates. Not accounting for clustering with highly clustered data results in standard errors being too small and consequently confidence intervals being too narrow, thereby increasing the likelihood of rejecting the null hypothesis when it is true. Clarke (2008) tested whether this risk of increasing Type I errors also occurs when standard regression techniques are used to analyse data with low levels of clustering (≤2 observations per group) and found that the standard errors of regression coefficients were underestimated by 10 to 15% with a continuous outcome and 25% with a binary outcome. Therefore the decision to not include neighbourhood as a level in this thesis may have had a similar impact.

Ultimately, the DASH study was not designed *a priori* to test neighbourhood effects. To have the statistical power necessary to address the aims of this thesis with certainty would require a substantially bigger study. Rather than give a definitive answer, this thesis adds to the (currently limited) evidence and debate in this field.

A further limitation of the DASH sample size was that although it large enough to stratify all analyses by gender but not large enough to fully examine interactions between covariates. Interactions between each of the covariates and ethnicity, and each of the covariates and age, were tested but it was not possible to determine if differences by age differed by ethnicity, or conversely if differences by ethnicity varied by age. Furthermore, the wide confidence intervals in the overweight and obesity analyses highlight that a larger sample would be required to have more precise estimates.

Sample attrition is a potential problem faced by all studies with a longitudinal design (Ahern and Le Brocque, 2005). If the pupils who participated in Wave 1 but not Wave 2 differed from those who participated in both Waves then this could have resulted in bias. A comparison of BMI and waist between those who participated in W2 and those who did not was undertaken. For boys, there was no difference in mean BMI or waist between those who participated in W2 and those who did not. For girls, compared to those who did participate those who did not had a significantly higher mean BMI (21.5 kg/m^2 versus 21.0 kg/m^2) and larger mean waist (67.3cm versus 66.1cm). This pattern did not differ by ethnicity, therefore if these individuals had participated in Wave 2 we would expect the mean body size measures to be slightly increased but would not expect the ethnic patterns observed to change.

Missing individual and family data were the result of item non-response. In this thesis missing data were handled by imputing a single dataset with error which is thought to be preferable to conducting complete case analysis or using a dataset with imputed means. The ideal approach would have been to use multiple imputation; conducting analysis on several datasets then combining the results would have given increased confidence in the imputed values and hence the results. Such methods are not straight-forward and analysis times are greatly increased. Given that this was not a methodological thesis, and the focus was on examining hypotheses related to determinants of body size, the pragmatic decision was taken to impute only a single dataset. Missing school data resulted from some schools not having Ofsted inspections around the time of the DASH study. The proportion of missing data on school ethos measures taken from the Ofsted reports was high but these variables were included in the univariate analyses as they were the only measures of ethos available. It is acknowledged that the lack of association between the ethos measures and body size may be due in part to the weaknesses in the data used.

8.5 Implications for future research and policy

The prevalence of obesity worldwide has increased substantially in the last few decades. Although obesity rates have stabilised or declined in the past decade for children and adolescents in many European countries, including England, this does not imply that rates will not continue to increase in the future (the obesity epidemic to date has been nonlinear) or that rates are declining in all groups (in England obesity rates continued to rise for low SES children) (Rokholm et al., 2010). Overall, there was no sign of a reversal in the obesity epidemic and Rokholm et al. conclude that the current picture is one of ‘stability at an unacceptably high level’ (2010, p843). The relatively large waists of the DASH pupils irrespective of ethnicity or SES signals the importance of policy changes and interventions which benefit all young people, rather than a targeted approach aimed at particular groups. This section considers potential implications of this thesis for policy and future research.

The environmental impact on body size and related behaviours needs to be better understood

Despite the general lack of association between contextual factors and body size in this thesis, the widespread nature of the obesity epidemic suggests the importance of upstream, environmental determinants. Egger and Swinburn (1997, p477) propose that obesity should be viewed as ‘a normal response to an abnormal environment, rather than vice versa’. It is unlikely that interventions targeting individual behaviours will be successful without changes to the wider environment. Egger and Swinburn (1997, p479) also astutely state that ‘historically epidemics have been controlled only after environmental factors have been modified’. The large increase in publications on neighbourhood influences on body size in young people demonstrates that it is a rapidly growing area of enquiry, however research on school effects on body size remains limited. It will only be possible to develop effective interventions if the key contextual drivers of obesity and its related behaviours are better understood and measured.

A recent Government White Paper ‘Healthy lives, healthy people: our strategy for public health in England’ (HM Government, 2010) explicitly acknowledges the role of schools in promoting health. However few intervention studies to date have focused on ethnic minority children and so little is known about the most appropriate interventions. The DEAL study, which was designed in light of findings from DASH, aims to identify culturally acceptable, effective interventions to prevent obesity in ethnic minority children (Maynard et al., 2009).

Interventions need to start at a young age and involve the family

Obesity is difficult to treat once established, and there is a dose-response relationship between number of years an individual is obese and all-cause, cardiovascular and cancer mortality (Abdullah et al., 2011). It is therefore imperative that preventative strategies aim to delay its onset. From the findings in this thesis, waiting until adolescence is arguably too late, particularly for Black Caribbean, Nigerian/Ghanaian, and Other African girls. Furthermore, as discussed, the findings in this thesis also suggest that central adiposity was already present for many pupils irrespective of ethnic group in early adolescence.

The association between maternal and child body size highlights the importance of involving the family in interventions to reduce obesogenic behaviours, and also signifies the potential of prevention programs to have a multigenerational impact (Oken and Gillman, 2003). Irrespective of effects on adiposity, healthy dietary behaviours and physical activity have many health benefits and families could play a key role in supporting these behaviours. Places of worship, which are often a focal point of community life for many ethnic minority groups, could be an effective place for interventions at a family or community level and the DEAL study is assessing the appropriateness of this strategy in London (Maynard et al., 2009). Eating breakfast is believed to have many benefits as part of a healthy lifestyle in addition to being associated with a lower risk of overweight and obesity; young people who eat breakfast tend to have better overall nutritional profiles than those who do not, and tend to have better cognitive function and school attendance (Rampersaud et al., 2005). Interventions to increase breakfast eating could be considered. Fruit and vegetables are an important part of a healthy diet, and may help prevent CVD and some cancers independent of any effect on adiposity (Jensen et al., 2008, Maynard et al., 2003, Mozaffarian et al., 2008, Steinmetz and Potter, 1996). Similarly, exercise has many health benefits in addition to helping maintain a healthy weight. These include beneficial effects on blood pressure, psychological well-being, and fitness, and the prevention of type 2 diabetes, coronary heart disease, and some cancers (Vuori, 2001, Warburton et al., 2006). Thus, interventions to improve diet and increase activity levels would have health benefits for both normal and overweight adolescents.

In terms of specifically tackling obesity, it has been proposed that while both sides of the energy balance equation are important in maintaining a healthy weight, interventions to tackle childhood obesity should focus on limiting energy intake rather than increasing physical activity as ‘the modern world makes it very easy to out-eat exercise, and nearly impossible to out-exercise excessive eating’ (Katz, 2011, p33).

Early life factors are likely to be important drivers of ethnic differences in body size

The range of characteristics examined in this thesis did not explain ethnic differences in body size trends. A better understanding of the exposures which drive ethnic differences in both prenatal and early life is necessary to elucidate the reasons for ethnic inequalities in health in later life.

It is important to consider that the ethnic group categories of importance in twenty years time, if any, are very unlikely to be those of today (Finney and Simpson, 2009). Cultural diversity in Britain is increasing as a result of immigration and natural growth (i.e. more births than deaths) of ethnic minority populations (Finney and Simpson, 2009). It is predicted that the UK will be more ethnically diverse in 2051 than 2001, and that this increase will be nationwide, not restricted to specific areas (Rees et al., 2011). As time passes, migrants who have settled in the UK have children and their identity changes from being migrants, to being members of ethnic communities who have ties to their country of origin but also to the UK (Rees et al., 2011). The future ethnic composition of the UK will depend both on where migrants come from and on the extent to which they marry across ethnic lines (Waters, 2000).

BMI on its own is not adequate for determining adiposity in adolescents

BMI is the most widely used measure of body size in epidemiological studies however it gives no information on fat distribution or body composition. This thesis concurs with McCarthy et al. (2003) in finding that trends in waist circumference have exceeded those of BMI in the past two decades in the UK. Waist circumference, as a relatively straight forward proxy measure of central adiposity, should therefore be included in future studies of body size in children and adolescents in the UK.

Appendix

Table 8.2 Residential neighbourhood land use and body size

		Boys		Girls	
		BMI SDS	Waist SDS	BMI SDS	Waist SDS
Domestic Buildings	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	0.01 (-0.09-0.11)	0.07 (-0.05-0.19)	0.05 (-0.05-0.14)	0.10 (-0.03-0.23)
	Q3	0.02 (-0.09-0.12)	0.08 (-0.05-0.20)	0.05 (-0.05-0.15)	0.10 (-0.03-0.24)
	Q4	0.03 (-0.09-0.15)	0.06 (-0.07-0.19)	0.00 (-0.10-0.11)	0.02 (-0.13-0.16)
Non-domestic buildings	Q1 (lowest density)	Ref	Ref	Ref^	Ref
	Q2	0.04 (-0.06-0.14)	0.06 (-0.05-0.18)	0.03 (-0.05-0.12)	0.03 (-0.09-0.16)
	Q3	0.02 (-0.09-0.13)	0.04 (-0.08-0.16)	-0.06 (-0.15-0.04)	0.01 (-0.12-0.14)
	Q4	0.06 (-0.05-0.17)	0.03 (-0.10-0.16)	-0.01 (-0.12-0.10)	0.06 (-0.08-0.21)
Roads	Q1 (lowest density)	Ref^	Ref^	Ref	Ref
	Q2	-0.04 (-0.13-0.05)	0.03 (-0.08-0.14)	0.05 (-0.04-0.14)	0.09 (-0.04-0.21)
	Q3	0.05 (-0.05-0.15)	0.11 (-0.01-0.22)	0.02 (-0.07-0.11)	0.06 (-0.07-0.19)
	Q4	0.07 (-0.04-0.18)	0.05 (-0.08-0.17)	0.03 (-0.07-0.13)	0.08 (-0.05-0.22)
Green Space	Q1 (lowest density)	Ref	Ref	Ref	Ref
	Q2	-0.03 (-0.12-0.07)	-0.11 (-0.22-0.01)	0.06 (-0.03-0.16)	-0.05 (-0.18-0.09)
	Q3	0.04 (-0.06-0.15)	-0.04 (-0.16-0.09)	0.00 (-0.10-0.10)	-0.09 (-0.23-0.04)
	Q4	0.01 (-0.10-0.12)	-0.06 (-0.19-0.06)	0.02 (-0.09-0.12)	-0.03 (-0.17-0.11)
Domestic Gardens	Q1 (lowest density)	Ref	Ref	Ref^	Ref
	Q2	-0.08 (-0.21-0.04)	-0.13 (-0.26-0.01)	0.03 (-0.08-0.14)	-0.01 (-0.16-0.13)
	Q3	-0.11 (-0.23-0.01)	-0.10 (-0.23-0.04)	0.04 (-0.07-0.16)	0.04 (-0.11-0.19)
	Q4	-0.13 (-0.26 - -0.01)*	-0.09 (-0.23-0.04)	-0.02 (-0.14-0.09)	-0.02 (-0.18-0.13)

*Significantly different to reference category ($p<0.05$)

^ Significant interaction between variable and ethnicity. P-values for the interaction terms are given below, full details in text.

Boys Road density BMI SDS p=0.009; Waist SDS p=0.017

Girls: Non-domestic buildings BMI SDS p=0.008; Domestic Gardens p=0.019

Table 8.3 Boys: BMI SDS multivariate models

(Models 7-10 in next table)

		Model 1 - SES	Model 2 - Cultural Identity	Model 3 - Pupils' behaviour	Model 4 - Parental behaviour	Model 5 - Neighbourhood subjective	Model 6 - Neighbourhood objective
Standard of living	Q1(ref)						
	Q2	-0.00 (-0.07-0.06)	-0.00 (-0.07-0.06)	-0.00 (-0.07-0.06)	-0.00 (-0.07-0.06)	-0.00 (-0.07-0.06)	-0.00 (-0.07-0.06)
	Q3	-0.00 (-0.07-0.07)	-0.00 (-0.07-0.07)	-0.00 (-0.07-0.07)	-0.01 (-0.08-0.06)	-0.01 (-0.08-0.06)	-0.01 (-0.08-0.06)
	Q4	-0.10 (-0.19--0.01)*	-0.10 (-0.19--0.01)*	-0.10 (-0.19--0.01)*	-0.11 (-0.20--0.02)*	-0.11 (-0.20--0.02)*	-0.11 (-0.20--0.02)*
Family type & employment	2 parent, working (ref)						
	1 parent, working	0.06 (-0.03-0.14)	0.06 (-0.03-0.14)	0.05 (-0.03-0.14)	0.06 (-0.09-0.20)	0.06 (-0.09-0.20)	0.06 (-0.08-0.21)
	2 parent, no work	-0.05 (-0.16-0.06)	-0.04 (-0.15-0.07)	-0.04 (-0.15-0.07)	-0.04 (-0.15-0.07)	-0.04 (-0.15-0.07)	-0.04 (-0.15-0.07)
	1 parent, no work	0.08 (-0.02-0.18)	0.08 (-0.02-0.18)	0.07 (-0.03-0.17)	0.07 (-0.08-0.23)	0.08 (-0.08-0.23)	0.08 (-0.07-0.23)
Generational status	Born in UK (ref)						
	<10yrs in UK		-0.06 (-0.22-0.09)	-0.04 (-0.19-0.12)	-0.04 (-0.20-0.12)	-0.04 (-0.20-0.12)	-0.04 (-0.20-0.12)
Friend's of different ethnicity	Quite a lot (ref)						
	Most or all		0.04 (-0.04-0.12)	0.04 (-0.04-0.12)	0.03 (-0.04-0.11)	0.04 (-0.04-0.11)	0.04 (-0.04-0.11)
	Some or none		-0.04 (-0.10-0.01)	-0.04 (-0.09-0.01)	-0.04 (-0.09-0.01)	-0.04 (-0.09-0.01)	-0.04 (-0.09-0.01)
Fruit and Veg	>= 5 per day (Ref)						
	1-4 per day			0.04 (-0.02-0.09)	0.04 (-0.02-0.09)	0.04 (-0.02-0.09)	0.04 (-0.02-0.09)
	<1 per day			-0.01 (-0.08-0.06)	-0.01 (-0.08-0.05)	-0.01 (-0.08-0.06)	-0.01 (-0.08-0.06)
Eat Breakfast	Everyday (ref)						
	Not everyday			0.34 (0.21-0.46)*	0.33 (0.21-0.46)*	0.33 (0.20-0.45)*	0.34 (0.21-0.46)*
Activity sessions	Q1 (ref)						
	Q2			-0.04 (-0.10-0.02)	-0.04 (-0.10-0.02)	-0.04 (-0.10-0.02)	-0.04 (-0.10-0.02)
	Q3			-0.04 (-0.10-0.02)	-0.04 (-0.10-0.03)	-0.04 (-0.10-0.03)	-0.04 (-0.10-0.03)
	Q4			-0.01 (-0.08-0.06)	-0.01 (-0.08-0.06)	-0.01 (-0.08-0.06)	-0.01 (-0.08-0.06)
Smoking	Never tried (Ref)						
	Tried Once			0.03 (-0.03-0.09)	0.03 (-0.03-0.09)	0.03 (-0.03-0.09)	0.03 (-0.04-0.09)
	Given-up			0.04 (-0.10-0.17)	0.03 (-0.10-0.17)	0.03 (-0.10-0.16)	0.02 (-0.11-0.16)
	Smoker			0.01 (-0.11-0.12)	0.01 (-0.10-0.12)	0.01 (-0.10-0.12)	0.01 (-0.11-0.12)

Mum overweight	No (ref)						
	Yes				0.12 (0.02-0.23)*	0.12 (0.02-0.22)*	0.12 (0.02-0.23)*
	Don't know				0.01 (-0.09-0.11)	0.01 (-0.09-0.11)	0.01 (-0.09-0.11)
Mum smoking	No (ref)						
	Yes				0.07 (-0.04-0.18)	0.07 (-0.04-0.18)	0.07 (-0.04-0.18)
Dad overweight	No (Ref)						
	Yes				-0.02 (-0.13-0.10)	-0.02 (-0.14-0.09)	-0.02 (-0.14-0.09)
	Don't know				0.02 (-0.10-0.14)	0.02 (-0.11-0.14)	0.02 (-0.11-0.14)
Dad smoking	No (ref)						
	Yes				0.01 (-0.08-0.10)	0.01 (-0.08-0.10)	0.00 (-0.09-0.09)
Like Area	Agree (Ref)						
	Disagree					0.01 (-0.06-0.09)	0.01 (-0.06-0.09)
Safe Day	Agree (Ref)						
	Disagree					0.05 (-0.03-0.12)	0.05 (-0.03-0.12)
Safe night	Agree (Ref)						
	Disagree					-0.00 (-0.06-0.05)	-0.00 (-0.06-0.05)
Good area	Agree (Ref)						
	Disagree					-0.01 (-0.07-0.05)	-0.01 (-0.07-0.05)
IMD	Q1,2,3, 4 (Ref)						
	Q5						-0.03 (-0.11-0.04)
Ethnic Density	White UK Q1,2,3 (ref)						
	White UK Q4						-0.15 (-0.37-0.07)
	Black Caribbean Q1,2,3 (ref)						
	Black Caribbean Q4						0.16 (-0.06-0.37)
	Nigerian/Ghanaian Q1,2,3 (ref)						
	Black Caribbean Q4						-0.07 (-0.41-0.28)

	Other African Q1,2,3 (ref)						
	Other African Q4						0.28 (-0.01-0.57)
	Indian Q1,2,3 (ref)						
	Indian Q4						0.13 (-0.21-0.46)
	Pak/Bang Q1,2,3 (ref)						
	Pak/Bang Q4						-0.08 (-0.35-0.20)

*Significantly different to reference category (p<0.05)

Table 9.2 (Continued) Boys BMI SDS Models 7-10

		Model 7 - School sex and religion	Model 8 - School academic performance & absence	Model 9 - School ethnic density	Model 10 - academic performance, absence, ethnic density
Standard of living	Q1(ref)				
	Q2	-0.00 (-0.07-0.06)	-0.01 (-0.07-0.06)	-0.00 (-0.07-0.06)	-0.01 (-0.07-0.06)
	Q3	-0.01 (-0.08-0.06)	-0.02 (-0.09-0.05)	-0.01 (-0.08-0.06)	-0.02 (-0.09-0.05)
	Q4	-0.11 (-0.20--0.02)*	-0.12 (-0.21--0.03)*	-0.11 (-0.20--0.02)*	-0.12 (-0.21--0.02)*
Family type & employment	2 parent, working (ref)				
	1 parent, working	0.06 (-0.09-0.21)	0.06 (-0.09-0.21)	0.07 (-0.08-0.21)	0.06 (-0.08-0.21)
	2 parent, not working	-0.04 (-0.15-0.07)	-0.04 (-0.15-0.07)	-0.04 (-0.15-0.07)	-0.04 (-0.15-0.08)
	1 parent, not working	0.08 (-0.07-0.23)	0.08 (-0.07-0.23)	0.08 (-0.07-0.24)	0.08 (-0.07-0.24)
Generational status	Born in UK (ref)				
	<10yrs in UK	-0.04 (-0.20-0.12)	-0.04 (-0.20-0.11)	-0.04 (-0.20-0.11)	-0.04 (-0.20-0.11)
Friend's of different ethnicity	Quite a lot (ref)				
	Most or all	0.04 (-0.04-0.11)	0.03 (-0.05-0.11)	0.04 (-0.04-0.11)	0.03 (-0.05-0.11)
	Some or none	-0.04 (-0.09-0.01)	-0.04 (-0.09-0.01)	-0.04 (-0.09-0.01)	-0.04 (-0.09-0.01)
Fruit and Veg	>= 5 per day (Ref)				
	1-4 per day	0.04 (-0.02-0.09)	0.04 (-0.02-0.09)	0.04 (-0.02-0.09)	0.03 (-0.02-0.09)
	<1 per day	-0.01 (-0.08-0.06)	-0.01 (-0.08-0.06)	-0.01 (-0.08-0.05)	-0.02 (-0.08-0.05)
Eat Breakfast	Everyday (ref)				
	Not everyday	0.34 (0.21-0.46)*	0.34 (0.22-0.47)*	0.33 (0.21-0.46)*	0.34 (0.21-0.46)
Activity sessions	Q1 (ref)				
	Q2	-0.04 (-0.10-0.02)	-0.05 (-0.11-0.02)	-0.04 (-0.10-0.02)	-0.05 (-0.11-0.01)
	Q3	-0.04 (-0.10-0.03)	-0.04 (-0.10-0.03)	-0.03 (-0.10-0.03)	-0.04 (-0.10-0.03)
	Q4	-0.01 (-0.08-0.07)	-0.01 (-0.08-0.06)	-0.01 (-0.08-0.07)	-0.01 (-0.08-0.06)
Smoking	Never tried (Ref)				
	Tried Once	0.02 (-0.04-0.09)	0.03 (-0.04-0.09)	0.03 (-0.04-0.09)	0.02 (-0.04-0.09)
	Given-up	0.02 (-0.11-0.16)	0.02 (-0.11-0.16)	0.02 (-0.11-0.16)	0.02 (-0.11-0.16)
	Smoker	0.01 (-0.11-0.12)	0.01 (-0.10-0.13)	0.01 (-0.11-0.12)	0.01 (-0.10-0.13)
Mum overweight	No (ref)				
	Yes	0.12 (0.02-0.23)*	0.13 (0.02-0.23)*	0.12 (0.02-0.22)*	0.13 (0.02-0.23)*
	Don't know	0.01 (-0.09-0.11)	0.01 (-0.09-0.11)	0.01 (-0.09-0.11)	0.02 (-0.09-0.12)*

	Not resident	0.10 (-0.05-0.24)	0.10 (-0.05-0.24)	0.10 (-0.04-0.24)	
Mum smoking	No (ref)				
	Yes	0.07 (-0.04-0.18)	0.07 (-0.04-0.18)	0.07 (-0.04-0.18)	0.07 (-0.04-0.18)
Dad overweight	No (ref)				
	Yes	-0.02 (-0.14-0.09)	-0.02 (-0.14-0.09)	-0.02 (-0.13-0.10)	-0.02 (-0.13-0.10)
	Don't know	0.01 (-0.11-0.14)	0.02 (-0.10-0.14)	0.02 (-0.10-0.14)	0.02 (-0.10-0.14)
	Not resident	-0.03 (-0.18-0.12)	-0.03 (-0.18-0.12)	-0.03 (-0.18-0.12)	
Dad smoking	No (ref)				
	Yes	0.00 (-0.09-0.09)	0.00 (-0.09-0.09)	0.00 (-0.09-0.09)	0.00 (-0.09-0.09)
Like Area	Agree (Ref)				
	Disagree	0.01 (-0.06-0.09)	0.01 (-0.06-0.08)	0.01 (-0.06-0.08)	0.01 (-0.07-0.08)
Safe Day	Agree (Ref)				
	Disagree	0.05 (-0.03-0.12)	0.05 (-0.03-0.12)	0.05 (-0.03-0.12)	0.05 (-0.03-0.12)
Safe night	Agree (Ref)				
	Disagree	-0.00 (-0.06-0.05)	-0.01 (-0.06-0.05)	-0.00 (-0.06-0.05)	-0.00 (-0.06-0.05)
Good area	Agree (Ref)				
	Disagree	-0.01 (-0.07-0.05)	-0.01 (-0.07-0.05)	-0.01 (-0.07-0.05)	-0.01 (-0.07-0.05)
IMD	Q1,2,3, 4 (Ref)				
	Q5	-0.03 (-0.11-0.05)	-0.04 (-0.12-0.04)	-0.03 (-0.11-0.04)	-0.04 (-0.11-0.04)
Neighbourhood Ethnic Density	White UK Q1,2,3 (Ref)				
	White UK Q4	-0.15 (-0.37-0.08)	-0.13 (-0.35-0.09)	-0.14 (-0.38-0.10)	-0.12 (-0.35-0.12)
	Black Caribbean Q1,2,3 (Ref)				
	Black Caribbean Q4	0.16 (-0.06-0.37)	0.15 (-0.06-0.37)	0.16 (-0.06-0.38)	0.15 (-0.07-0.37)
	Nigerian/Ghanaian Q1,2,3 (Ref)				
	Nig/Gha Q4	-0.07 (-0.42-0.27)	-0.01 (-0.36-0.33)	-0.14 (-0.50-0.21)	-0.10 (-0.46-0.26)
	Other African Q1,2,3 (Ref)				
	Other African Q4	0.29 (-0.01-0.58)	0.28 (-0.02-0.57)	0.28 (-0.02-0.57)	0.28 (-0.02-0.57)
	Indian Q1,2,3 (Ref)				

	Indian Q4	0.14 (-0.20-0.48)	0.13 (-0.21-0.47)	0.14 (-0.20-0.48)	0.13 (-0.21-0.47)
	Pak/Bang Q1,2,3 (Ref)				
	Pak/Bang Q4	-0.06 (-0.34-0.21)	-0.07 (-0.34-0.20)	-0.04 (-0.32-0.23)	-0.04 (-0.31-0.24)
School religion	Non-denominational (Ref)				
	Church of England	-0.12 (-0.48-0.24)			
	Catholic	0.02 (-0.19-0.23)			
School sex	Mixed (Ref)				
	All Boys	0.08 (-0.07-0.22)			
Academic Performance	Q1 (Ref)				
	Q2		0.17 (0.02-0.32)*		0.18 (0.02-0.33)*
	Q3		0.23 (0.06-0.40)*		0.23 (0.05-0.40)*
	Q4		0.21 (0.04-0.37)*		0.19 (0.03-0.36)*
Unauthorised absence	Q1 (lowest: Ref)				
	Q2		-0.07 (-0.14-0.01)		-0.05 (-0.13-0.02)
	Q3		-0.08 (-0.17--0.00)*		-0.08 (-0.16-0.01)
	Q4		-0.09 (-0.19-0.00)		-0.09 (-0.19-0.01)
Ethnic Density*	White UK Q1,2,3 (Ref)				
	White UK Q4			-0.01 (-0.21-0.18)	-0.02 (-0.23-0.18)
	Black Caribbean Q1,2,3 (Ref)				
	Black Caribbean Q4			0.01 (-0.17-0.19)	0.01 (-0.18-0.19)
	Nigerian/Ghanaian Q1,2,3 (Ref)				
	Nigerian/Ghanaian Q4			0.27 (-0.04-0.58)	0.29 (-0.02-0.60)
	Other African Q1,2,3 (Ref)				
	Other African Q4			0.02 (-0.20-0.23)	0.02 (-0.20-0.23)
	Indian Q1,2,3 (Ref)				
	Indian Q4			-0.17 (-0.41-0.06)	-0.10 (-0.35-0.14)
	Pak/Bang Q1,2,3 (Ref)				
	Pak/Bang Q4			-0.15 (-0.39-0.09)	-0.16 (-0.41-0.10)

Table 8.4 Boys: Waist SDS multivariate models

(Models 7-10 continued in next table)

		Model 1 - SES	Model 2 - Acculturation	Model 3 - Pupils' behaviour	Model 4 - Parental behaviour	Model 5 - Neighbourhood subjective	Model 6 - Neighbourhood objective
Standard of living	Q1(ref)						
	Q2	-0.00 (-0.09-0.08)	-0.01 (-0.09-0.08)	-0.01 (-0.10-0.08)	-0.01 (-0.10-0.08)	-0.01 (-0.09-0.08)	-0.01 (-0.10-0.08)
	Q3	0.01 (-0.08-0.10)	0.01 (-0.08-0.10)	0.00 (-0.08-0.09)	-0.00 (-0.09-0.09)	0.00 (-0.09-0.09)	-0.00 (-0.09-0.09)
	Q4	-0.10 (-0.21-0.02)	-0.09 (-0.20-0.02)	-0.10 (-0.21-0.01)	-0.11 (-0.23-0.00)	-0.11 (-0.22-0.00)	-0.12 (-0.23--0.00)*
Family type & employment	2 parent, working (ref)						
	1 parent, working	0.10 (-0.01-0.21)	0.10 (-0.01-0.21)	0.09 (-0.02-0.20)	0.20 (0.02-0.38)*	0.19 (0.01-0.38)*	0.19 (0.01-0.38)*
	2 parent, not working	0.01 (-0.12-0.15)	0.02 (-0.12-0.16)	0.02 (-0.11-0.16)	0.02 (-0.12-0.16)	0.02 (-0.12-0.16)	0.02 (-0.12-0.16)
	1 parent, not working	0.08 (-0.05-0.21)	0.08 (-0.04-0.21)	0.07 (-0.06-0.19)	0.18 (-0.01-0.37)	0.18 (-0.01-0.37)	0.18 (-0.01-0.37)
	Other structure	-0.05 (-0.29-0.19)	-0.05 (-0.29-0.20)	-0.06 (-0.31-0.18)			
Generational status	Born in UK (ref)						
	<10yrs in UK		-0.05 (-0.19-0.09)	-0.03 (-0.17-0.12)	-0.03 (-0.17-0.11)	-0.03 (-0.17-0.11)	-0.03 (-0.17-0.11)
Friend's of different ethnicity	Quite a lot (ref)						
	Most or all		0.02 (-0.09-0.12)	0.02 (-0.08-0.12)	0.01 (-0.09-0.12)	0.02 (-0.09-0.12)	0.02 (-0.09-0.12)
	Some or none		-0.03 (-0.10-0.03)	-0.03 (-0.10-0.03)	-0.03 (-0.10-0.03)	-0.03 (-0.10-0.04)	-0.03 (-0.10-0.04)
Fruit and Veg	>= 5 per day (Ref)						
	1-4 per day			0.05 (-0.02-0.13)	0.05 (-0.03-0.12)	0.05 (-0.03-0.12)	0.05 (-0.03-0.12)
	<1 per day			-0.03 (-0.12-0.05)	-0.04 (-0.13-0.05)	-0.04 (-0.13-0.05)	-0.04 (-0.13-0.05)
Eat Breakfast	Everyday (ref)						
	Not everyday			0.25 (0.14-0.37)*	0.25 (0.14-0.36)*	0.25 (0.14-0.37)*	0.26 (0.15-0.37)*
Activity sessions	Q1 (ref)						
	Q2			-0.07 (-0.15-0.01)	-0.07 (-0.15-0.01)	-0.07 (-0.15-0.01)	-0.06 (-0.15-0.02)
	Q3			-0.09 (-0.18--0.01)*	-0.09 (-0.18--0.01)*	-0.10 (-0.18--0.01)*	-0.09 (-0.18--0.01)*

	Q4			-0.07 (-0.16-0.03)	-0.07 (-0.17-0.02)	-0.07 (-0.17-0.02)	-0.07 (-0.17-0.02)
Smoking	Never tried (Ref)						
	Tried Once			0.05 (-0.04-0.13)	0.04 (-0.04-0.12)	0.04 (-0.04-0.13)	0.04 (-0.04-0.13)
	Given-up			-0.01 (-0.19-0.16)	-0.02 (-0.19-0.16)	-0.01 (-0.19-0.16)	-0.02 (-0.20-0.16)
	Smoker			0.00 (-0.15-0.15)	0.00 (-0.14-0.15)	0.01 (-0.14-0.16)	0.01 (-0.14-0.16)
Mum overweight	No (ref)						
	Yes				0.19 (0.06-0.32)*	0.19 (0.06-0.33)*	0.19 (0.06-0.33)*
	Don't know				0.04 (-0.09-0.18)	0.05 (-0.09-0.18)	0.05 (-0.09-0.18)
Mum smoking	No (ref)						
	Yes				0.09 (-0.04-0.22)	0.09 (-0.04-0.21)	0.08 (-0.05-0.21)
Dad overweight	No (ref)						
	Yes				0.09 (-0.05-0.24)	0.10 (-0.05-0.25)	0.10 (-0.05-0.25)
	Don't know				0.08 (-0.08-0.25)	0.08 (-0.08-0.24)	0.08 (-0.08-0.24)
Dad smoking	No (ref)						
	Yes				0.04 (-0.07-0.15)	0.04 (-0.06-0.15)	0.04 (-0.07-0.15)
Like Area	Agree (Ref)						
	Disagree					-0.05 (-0.15-0.04)	-0.06 (-0.15-0.04)
Safe Day	Agree (Ref)						
	Disagree					0.03 (-0.07-0.13)	0.02 (-0.08-0.12)
Safe night	Agree (Ref)						
	Disagree					-0.02 (-0.09-0.05)	-0.02 (-0.09-0.05)
Good area	Agree (Ref)						
	Disagree					-0.03 (-0.11-0.04)	-0.04 (-0.12-0.04)
IMD	Q1,2,3, 4 (Ref)						
	Q5						0.01 (-0.08-0.10)
Ethnic Density	White UK Q1,2,3 (ref)						
	White UK Q4						-0.22 (-0.46-0.01)
	Black Caribbean Q1,2,3						

	Black Caribbean Q4						0.12 (-0.11-0.35)
	Nigerian/Ghanaian Q1,2,3						
	Black Caribbean Q4						-0.06 (-0.40-0.29)
	Other African Q1,2,3						
	Other African Q4						0.19 (-0.12-0.51)
	Indian Q1,2,3						
	Indian Q4						0.25 (-0.08-0.58)
	Pak/Bang Q1,2,3						
	Pak/Bang Q4						-0.09 (-0.38-0.20)

*Significantly different to reference category (p<0.05)

Table 9.3 (continued) Boys Waist SDS Models 7-10

		Model 7 - School sex and religion	Model 8 - School academic performance & absence	Model 9 - School ethnic density	Model 10 - academic performance, absence, ethnic density
Standard of living	Q1(ref)				
	Q2	-0.01 (-0.10-0.08)	-0.01 (-0.09-0.08)	-0.01 (-0.10-0.08)	-0.01 (-0.09-0.08)
	Q3	0.00 (-0.09-0.09)	-0.00 (-0.09-0.09)	0.00 (-0.09-0.09)	-0.00 (-0.09-0.09)
	Q4	-0.11 (-0.23-0.00)	-0.11 (-0.23--0.00)*	-0.11 (-0.23-0.00)	-0.11 (-0.22-0.00)
Family type & employment	2 parent, working (ref)				
	1 parent, working	0.19 (0.01-0.38)*	0.18 (-0.00-0.36)	0.20 (0.02-0.38)*	0.19 (0.01-0.37)*
	2 parent, not working	0.01 (-0.12-0.15)	0.03 (-0.11-0.17)	0.02 (-0.12-0.16)	0.03 (-0.11-0.17)
	1 parent, not working	0.18 (-0.01-0.37)	0.16 (-0.03-0.36)	0.18 (-0.01-0.37)	0.17 (-0.02-0.36)
Generational status	Born in UK (ref)				
	<10yrs in UK	-0.03 (-0.18-0.11)	-0.04 (-0.18-0.11)	-0.04 (-0.18-0.11)	-0.04 (-0.18-0.11)
Friend's of different ethnicity	Quite a lot (ref)				
	Most or all	0.02 (-0.09-0.12)	0.03 (-0.08-0.13)	0.02 (-0.09-0.12)	0.03 (-0.08-0.13)
	Some or none	-0.03 (-0.10-0.04)	-0.03 (-0.10-0.03)	-0.03 (-0.10-0.04)	-0.03 (-0.10-0.03)
Fruit and Veg	>= 5 per day (Ref)				
	1-4 per day	0.05 (-0.03-0.12	0.04 (-0.03-0.11)	0.04 (-0.03-0.11)	0.04 (-0.03-0.11)
	<1 per day	-0.04 (-0.13-0.05)	-0.04 (-0.13-0.05)	-0.05 (-0.14-0.04)	-0.05 (-0.13-0.04)
Eat Breakfast	Everyday (ref)				
	Not everyday	0.26 (0.14-0.37)*	0.26 (0.14-0.37)*	0.25 (0.14-0.37)*	0.25 (0.14-0.36)*
Activity sessions	Q1 (ref)				
	Q2	-0.06 (-0.15-0.02)	-0.07 (-0.15-0.02)	-0.06 (-0.15-0.02)	-0.06 (-0.14-0.02)
	Q3	-0.09 (-0.18--0.01)*	-0.09 (-0.17--0.00)*	-0.09 (-0.17--0.00)*	-0.08 (-0.17-0.00)
	Q4	-0.07 (-0.17-0.02)	-0.07 (-0.16-0.03)	-0.06 (-0.16-0.03)	-0.06 (-0.15-0.04)
Smoking	Never tried (Ref)				
	Tried Once	0.04 (-0.04-0.12)	0.05 (-0.04-0.13)	0.04 (-0.04-0.13)	0.05 (-0.04-0.13)
	Given-up	-0.02 (-0.20-0.16)	-0.03 (-0.20-0.15)	-0.02 (-0.20-0.15)	-0.03 (-0.20-0.15)

	Smoker	0.00 (-0.15-0.15)	0.01 (-0.14-0.16)	-0.01 (-0.14-0.16)	0.01 (-0.14-0.16)
Mum overweight	No (ref)				
	Yes	0.19 (0.06-0.33)*	0.20 (0.07-0.33)*	0.19 (0.06-0.32)*	0.19 (0.06-0.32)*
	Don't know	0.05 (-0.09-0.18)	0.04 (-0.09-0.17)	0.05 (-0.08-0.18)	0.04 (-0.09-0.17)
	Not resident	0.11 (-0.07-0.29)	0.11 (-0.07-0.28)	0.11 (-0.07-0.29)	0.11 (-0.07-0.29)
Mum smoking	No (ref)				
	Yes	0.08 (-0.05-0.21)	0.07 (-0.06-0.19)	0.08 (-0.05-0.21)	0.07 (-0.06-0.20)
Dad overweight	No (ref)				
	Yes	0.10 (-0.05-0.25)	0.10 (-0.04-0.25)	0.11 (-0.04-0.26)	0.11 (-0.04-0.26)
	Don't know	0.08 (-0.08-0.24)	0.09 (-0.07-0.25)	0.09 (-0.07-0.25)	0.09 (-0.07-0.26)
	Not resident			-0.12 (-0.30-0.06)	-0.11 (-0.29-0.07)
Dad smoking	No (ref)				
	Yes	0.04 (-0.07-0.14)	0.04 (-0.07-0.14)	0.04 (-0.07-0.14)	0.04 (-0.07-0.14)
Like Area	Agree (Ref)				
	Disagree	-0.06 (-0.15-0.04)	-0.06 (-0.16-0.04)	-0.06 (-0.16-0.03)	-0.07 (-0.16-0.03)
Safe Day	Agree (Ref)				
	Disagree	0.02 (-0.08-0.12)	0.03 (-0.07-0.13)	0.03 (-0.07-0.13)	0.04 (-0.06-0.13)
Safe night	Agree (Ref)				
	Disagree	-0.02 (-0.09-0.05)	-0.02 (-0.10-0.05)	-0.02 (-0.09-0.05)	-0.02 (-0.09-0.05)
Good area	Agree (Ref)				
	Disagree	-0.04 (-0.12-0.04)	-0.03 (-0.11-0.05)	-0.04 (-0.11-0.04)	-0.03 (-0.11-0.05)
IMD	Q1,2,3, 4 (Ref)				
	Q5	0.02 (-0.08-0.11)	0.01 (-0.08-0.10)	0.01 (-0.08-0.10)	0.01 (-0.08-0.10)
Ethnic Density	White UK Q1,2,3 (Ref)				
	White UK Q4	-0.23 (-0.47--0.00)*	-0.20 (-0.43-0.04)	-0.21 (-0.46-0.05)	-0.15 (-0.40-0.11)
	Black Caribbean Q1,2,3 (Ref)				
	Black Caribbean Q4	0.12 (-0.12-0.35)	0.12 (-0.11-0.36)	0.12 (-0.12-0.35)	0.12 (-0.12-0.35)
	Nigerian/Ghanaian Q1,2,3 (Ref)				
	Black Caribbean Q4	-0.05 (-0.40-0.30)	-0.01 (-0.36-0.33)	-0.08 (-0.45-0.28)	-0.05 (-0.41-0.32)

	Other African Q1,2,3 (Ref)				
	Other African Q4	0.21 (-0.11-0.52)	0.21 (-0.11-0.53)	0.18 (-0.14-0.50)	0.20 (-0.12-0.52)
	Indian Q1,2,3 (Ref)				
	Indian Q4	0.25 (-0.08-0.58)	0.29 (-0.04-0.62)	0.28 (-0.05-0.61)	0.31 (-0.02-0.64)
	Pak/Bang Q1,2,3 (Ref)				
	Pak/Bang Q4	-0.10 (-0.39-0.19)	-0.04 (-0.33-0.25)	0.01 (-0.29-0.31)	0.03 (-0.27-0.33)
School religion	Non-denominational (Ref)				
	Church of England	-0.28 (-0.66-0.10)			
	Catholic	-0.09 (-0.32-0.14)			
School sex	Mixed (Ref)				
	All Boys	-0.02 (-0.19-0.15)			
Academic Performance	Q1 (Ref)				
	Q2		0.01 (-0.19-0.20)		-0.02 (-0.23-0.18)
	Q3		0.21 (-0.01-0.42)		0.17 (-0.05-0.39)
	Q4		0.06 (-0.15-0.27)		0.01 (-0.22-0.21)
Unauthorised absence	Q1 (lowest: Ref)				
	Q2		-0.13 (-0.22--0.03)*		-0.11 (-0.20--0.01)*
	Q3		-0.08 (-0.19-0.03)		-0.05 (-0.17-0.06)
	Q4		0.12 (-0.01-0.25)		0.13 (-0.00-0.26)
Ethnic Density*	White UK Q1,2,3 (Ref)				
	White UK Q4			-0.04 (-0.28-0.20)	-0.15 (-0.40-0.11)
	Black Caribbean Q1,2,3 (Ref)				
	Black Caribbean Q4			0.02 (-0.20-0.24)	0.08 (-0.14-0.30)
	Nigerian/Ghanaian Q1,2,3 (Ref)				
	Nigerian/Ghanaian Q4			0.09 (-0.27-0.44)	0.09 (-0.27-0.45)
	Other African Q1,2,3 (Ref)				
	Other African Q4			0.07 (-0.20-0.34)	0.10 (-0.17-0.37)
	Indian Q1,2,3 (Ref)				

Indian Q4			-0.41 (-0.71--0.12)*	-0.36 (-0.66--0.06)*
Pak/Bang Q1,2,3 (Ref)				
Pak/Bang Q4			-0.40 (-0.71--0.10)*	-0.28 (-0.60-0.04)

*Significantly different to reference category (p<0.05)

Table 8.5 Girls: BMI SDS multivariate models

(models 7-11 in next table)

		Model 1 - SES	Model 2 - Acculturation	Model 3 - Pupils' behaviour	Model 4 - Parental behaviour	Model 5 - Neighbourhood subjective	Model 6 - Neighbourhood objective
Standard of living	Q1(ref)						
	Q2	-0.01 (-0.08-0.06)	-0.01 (-0.08-0.06)	-0.01 (-0.08-0.06)	-0.01 (-0.08-0.06)	-0.00 (-0.07-0.07)	-0.00 (-0.08-0.07)
	Q3	-0.00 (-0.07-0.07)	-0.00 (-0.07-0.07)	0.00 (-0.07-0.07)	-0.00 (-0.07-0.07)	-0.00 (-0.07-0.07)	-0.01 (-0.08-0.07)
	Q4	-0.03 (-0.12-0.06)	-0.03 (-0.12-0.06)	-0.02 (-0.11-0.07)	-0.03 (-0.12-0.06)	-0.02 (-0.11-0.06)	-0.03 (-0.12-0.06)
Family type & employment	2 parent, working (ref)						
	1 parent, working	-0.03 (-0.11-0.06)	-0.03 (-0.11-0.06)	-0.02 (-0.11-0.06)	-0.08 (-0.22-0.06)	-0.08 (-0.22-0.06)	-0.08 (-0.22-0.06)
	2 parent, not working	0.03 (-0.09-0.14)	0.03 (-0.09-0.14)	0.03 (-0.08-0.15)	0.03 (-0.08-0.15)	0.03 (-0.09-0.15)	0.03 (-0.09-0.14)
	1 parent, not working	0.03 (-0.07-0.12)	0.02 (-0.07-0.12)	0.02 (-0.07-0.12)	-0.03 (-0.18-0.12)	-0.03 (-0.18-0.12)	-0.03 (-0.18-0.12)
	Other structure	0.10 (-0.09-0.29)	0.10 (-0.09-0.28)	0.11 (-0.07-0.30)			
Generational status	Born in UK (ref)						
	<10yrs in UK		0.03 (-0.14-0.19)	0.05 (-0.12-0.21)	0.04 (-0.12-0.21)	0.04 (-0.12-0.21)	0.05 (-0.12-0.21)
Friend's of different ethnicity	Quite a lot (ref)						
	Most or all		0.06 (-0.01-0.14)	0.06 (-0.02-0.13)	0.06 (-0.02-0.14)	0.06 (-0.02-0.14)	0.06 (-0.02-0.14)
	Some or none		0.01 (-0.04-0.06)	0.01 (-0.03-0.06)	0.02 (-0.03-0.07)	0.02 (-0.03-0.07)	0.02 (-0.03-0.07)
Fruit and Veg	>= 5 per day (Ref)						
	1-4 per day			-0.05 (-0.10-0.01)	-0.05 (-0.11-0.00)	-0.05 (-0.11-0.01)	-0.05 (-0.11-0.00)
	<1 per day			-0.08 (-0.14--0.01)*	-0.08 (-0.15--0.02)*	-0.08 (-0.15--0.02)*	-0.09 (-0.15--0.02)*
Eat Breakfast	Everyday (ref)						
	Not everyday			0.36 (0.24-0.48)*	0.36 (0.24-0.47)*	0.36 (0.24-0.48)*	0.36 (0.24-0.48)*
Activity sessions	Q1 (ref)						
	Q2			0.03 (-0.03-0.09)	0.03 (-0.03-0.09)	0.03 (-0.03-0.09)	0.03 (-0.03-0.09)
	Q3			0.05 (-0.01-0.11)	0.05 (-0.01-0.11)	0.05 (-0.01-0.11)	0.05 (-0.02-0.11)
	Q4			0.06 (-0.01-0.13)	0.06 (-0.01-0.13)	0.06 (-0.01-0.13)	0.06 (-0.01-0.12)

Smoking	Never tried (Ref)						
	Tried Once			-0.01 (-0.07-0.05)	-0.01 (-0.08-0.05)	-0.01 (-0.08-0.05)	-0.02 (-0.08-0.04)
	Given-up			-0.09 (-0.21-0.03)	-0.09 (-0.21-0.03)	-0.08 (-0.20-0.04)	-0.08 (-0.20-0.04)
	Smoker			-0.05 (-0.15-0.05)	-0.05 (-0.15-0.05)	-0.05 (-0.15-0.05)	-0.05 (-0.15-0.04)
Mum overweight	No (ref)						
	Yes				0.09 (0.01-0.18)*	0.09 (0.01-0.18)*	0.09 (0.01-0.18)*
	Don't know				0.09 (-0.00-0.18)	0.09 (-0.00-0.18)	0.09 (-0.00-0.18)
Mum smoking	No (ref)				0.10 (-0.01-0.21)	0.10 (-0.01-0.21)	0.10 (-0.01-0.21)
	Yes						
Dad overweight	No (ref)						
	Yes				0.05 (-0.06-0.17)	0.05 (-0.06-0.17)	0.05 (-0.06-0.17)
	Don't know				-0.02 (-0.13-0.09)	-0.02 (-0.13-0.09)	-0.02 (-0.13-0.09)
Dad smoking	No (ref)						
	Yes				-0.04 (-0.12-0.05)	-0.04 (-0.13-0.05)	-0.04 (-0.13-0.05)
Like Area	Agree (Ref)						
	Disagree					-0.03 (-0.10-0.03)	-0.03 (-0.10-0.04)
Safe Day	Agree (Ref)						
	Disagree					0.01 (-0.06-0.08)	0.01 (-0.06-0.08)
Safe night	Agree (Ref)						
	Disagree					0.01 (-0.04-0.07)	0.01 (-0.04-0.07)
Good area	Agree (Ref)						
	Disagree					-0.04 (-0.09-0.02)	-0.04 (-0.09-0.02)
IMD	Q1,2,3, 4 (Ref)						
	Q5						0.02 (-0.05-0.09)
Ethnic Density	White UK Q1,2,3 (ref)						
	White UK Q4						0.00 (-0.23-0.24)
	Black Caribbean Q1,2,3						

Black Caribbean Q4						-0.15 (-0.33-0.03)
Nigerian/Ghanaian Q1,2,3						
Nig/Gha Q4						0.11 (-0.12-0.35)
Other African Q1,2,3						
Other African Q4						0.20 (-0.05-0.44)
Indian Q1,2,3						
Indian Q4						-0.07 (-0.38-0.25)
Pak/Bang Q1,2,3						
Pak/Bang Q4						0.19 (-0.21-0.60)

*Significantly different to reference category (p<0.05)

Table 9.4 (continued) Girls BMI SDS models 7-11

		Model 7 - School sex and religion	Model 8 - School academic performance & absence	Model 9 - School ethnic density	Model 10 - academic performance, absence, ethnic density	Model 11 - academic performance, absence, ethnic density, sch sex rel
Standard of living	Q1(ref)					
	Q2	-0.01 (-0.08-0.07)	-0.00 (-0.08-0.07)	-0.00 (-0.08-0.07)	-0.00 (-0.07-0.07)	-0.00 (-0.07-0.07)
	Q3	-0.00 (-0.07-0.07)	-0.01 (-0.08-0.06)	-0.01 (-0.08-0.06)	-0.01 (-0.08-0.06)	-0.00 (-0.08-0.07)
	Q4	-0.03 (-0.12-0.06)	-0.03 (-0.12-0.06)	-0.03 (-0.12-0.06)	-0.03 (-0.12-0.06)	-0.03 (-0.12-0.06)
Family type & employment	2 parent, working (ref)					
	1 parent, working	-0.08 (-0.21-0.06)	-0.08 (-0.22-0.06)	-0.08 (-0.22-0.05)	-0.08 (-0.22-0.06)	-0.08 (-0.22-0.06)
	2 parent, not working	0.03 (-0.09-0.15)	0.03 (-0.09-0.15)	0.03 (-0.09-0.14)	0.03 (-0.09-0.15)	0.03 (-0.09-0.15)
	1 parent, not working	-0.02 (-0.17-0.12)	-0.03 (-0.18-0.12)	-0.04 (-0.18-0.11)	-0.04 (-0.19-0.11)	-0.03 (-0.18-0.11)
Generational status	Born in UK (ref)					
	<10yrs in UK	0.09 (-0.08-0.25)	0.06 (-0.10-0.23)	0.05 (-0.12-0.21)	0.06 (-0.10-0.23)	0.09 (-0.08-0.25)
Friend's of different ethnicity	Quite a lot (ref)					
	Most or all	0.06 (-0.02-0.14)	0.06 (-0.02-0.13)	0.06 (-0.02-0.13)	0.06 (-0.02-0.13)	0.06 (-0.02-0.13)
	Some or none	0.02 (-0.03-0.07)	0.02 (-0.03-0.07)	0.02 (-0.03-0.07)	0.02 (-0.03-0.07)	0.02 (-0.03-0.07)
Fruit and Veg	>= 5 per day (Ref)					
	1-4 per day	-0.05 (-0.11-0.00)	-0.05 (-0.11-0.01)	-0.05 (-0.11-0.00)	-0.05 (-0.11-0.00)	-0.05 (-0.11-0.00)
	<1 per day	-0.08 (-0.15--0.02)*	-0.08 (-0.15--0.02)*	-0.08 (-0.15--0.02)*	-0.08 (-0.15--0.01)*	-0.08 (-0.15--0.01)*
Eat Breakfast	Everyday (ref)					
	Not everyday	0.36 (0.24-0.48)*	0.36 (0.24-0.48)*	0.36 (0.24-0.48)*	0.36 (0.24-0.48)*	0.36 (0.24-0.48)*
Activity sessions	Q1 (ref)					
	Q2	0.03 (-0.03-0.09)	0.03 (-0.03-0.09)	0.03 (-0.03-0.09)	0.03 (-0.03-0.09)	0.03 (-0.03-0.10)
	Q3	0.05 (-0.01-0.11)	0.05 (-0.02-0.11)	0.05 (-0.02-0.11)	0.05 (-0.02-0.11)	0.05 (-0.02-0.11)
	Q4	0.06 (-0.01-0.13)	0.06 (-0.01-0.13)	0.06 (-0.01-0.13)	0.06 (-0.01-0.13)	0.06 (-0.01-0.13)
Smoking	Never tried (Ref)					
	Tried Once	-0.02 (-0.08-0.04)	-0.02 (-0.08-0.04)	-0.01 (-0.08-0.05)	-0.01 (-0.08-0.05)	-0.01 (-0.08-0.05)
	Given-up	-0.08 (-0.20-0.04)	-0.08 (-0.20-0.04)	-0.07 (-0.19-0.05)	-0.07 (-0.19-0.05)	-0.07 (-0.19-0.05)

	Smoker	-0.05 (-0.15-0.05)	-0.06 (-0.16-0.04)	-0.06 (-0.15-0.04)	-0.06 (-0.16-0.04)	-0.06 (-0.15-0.04)
Mum overweight	No (ref)					
	Yes	0.09 (0.01-0.18)*	0.09 (0.01-0.18)*	0.09 (0.00-0.17)*	0.09 (0.00-0.17)*	0.09 (0.00-0.18)*
	Don't know	0.09 (-0.00-0.18)	0.09 (0.00-0.18)*	0.08 (-0.00-0.17)	0.09 (-0.00-0.18)	0.09 (-0.00-0.18)
	Not resident					
Mum smoking	No (ref)					
	Yes	0.11 (-0.00-0.21)	0.11 (0.00-0.22)*	0.10 (-0.01-0.21)	0.11 (-0.00-0.22)	0.10 (-0.00-0.21)
Dad overweight	No (ref)					
	Yes	0.05 (-0.06-0.17)	0.05 (-0.06-0.17)	0.05 (-0.06-0.17)	0.05 (-0.06-0.17)	0.05 (-0.06-0.17)
	Don't know	-0.02 (-0.13-0.09)	-0.03 (-0.14-0.09)	-0.03 (-0.14-0.09)	-0.03 (-0.14-0.08)	-0.03 (-0.14-0.08)
	Not resident					
Dad smoking	No (ref)					
	Yes	-0.04 (-0.13-0.05)	-0.03 (-0.12-0.06)	-0.03 (-0.12-0.06)	-0.03 (-0.12-0.06)	-0.03 (-0.12-0.06)
Like Area	Agree (Ref)					
	Disagree	-0.03 (-0.10-0.04)	-0.03 (-0.10-0.04)	-0.04 (-0.10-0.03)	-0.03 (-0.10-0.04)	-0.03 (-0.10-0.04)
Safe Day	Agree (Ref)					
	Disagree	0.01 (-0.06-0.08)	0.01 (-0.06-0.08)	0.01 (-0.06-0.08)	0.01 (-0.06-0.08)	0.01 (-0.06-0.08)
Safe night	Agree (Ref)					
	Disagree	0.01 (-0.04-0.07)	0.02 (-0.04-0.07)	0.01 (-0.04-0.06)	0.01 (-0.04-0.07)	0.01 (-0.04-0.07)
Good area	Agree (Ref)					
	Disagree	-0.04 (-0.10-0.02)	-0.04 (-0.10-0.02)	-0.04 (-0.09-0.02)	-0.04 (-0.09-0.02)	-0.04 (-0.10-0.02)
IMD	Q1,2,3, 4 (Ref)					
	Q5	0.02 (-0.05-0.09)	0.02 (-0.05-0.09)	0.02 (-0.05-0.09)	0.02 (-0.05-0.09)	0.01 (-0.06-0.09)
Ethnic Density	White UK Q1,2,3 (ref)					
	White UK Q4	0.01 (-0.22-0.24)	-0.00 (-0.24-0.24)	0.09 (-0.19-0.37)	0.09 (-0.19-0.37)	0.09 (-0.19-0.37)
	Black Caribbean Q1,2,3					
	Black Caribbean Q4	-0.14 (-0.32-0.04)	-0.15 (-0.33-0.04)	-0.14 (-0.32-0.05)	-0.13 (-0.32-0.05)	-0.12 (-0.31-0.06)
	Nigerian/Ghanaian Q1,2,3					
	Nig/Gha Q4	0.10 (-0.13-0.33)	0.11 (-0.13-0.34)	0.12 (-0.12-0.35)	0.11 (-0.12-0.35)	0.11 (-0.13-0.34)

	Other African Q1,2,3					
	Other African Q4	0.18 (-0.07-0.42)	0.19 (-0.06-0.43)	0.17 (-0.08-0.43)	0.16 (-0.09-0.42)	0.16 (-0.09-0.41)
	Indian Q1,2,3					
	Indian Q4	-0.05 (-0.37-0.26)	-0.07 (-0.38-0.25)	-0.06 (-0.38-0.26)	-0.05 (-0.37-0.27)	-0.04 (-0.36-0.28)
	Pak/Bang Q1,2,3					
	Pak/Bang Q4	0.19 (-0.21-0.60)	0.20 (-0.21-0.60)	0.08 (-0.33-0.50)	0.09 (-0.33-0.50)	0.08 (-0.34-0.49)
School religion	Non-denominational (Ref)					
	Church of England	-0.01 (-0.23-0.22)				0.02 (-0.21-0.25)
	Catholic	0.21 (0.02-0.40)*				0.22 (0.02-0.42)*
School sex	Mixed (Ref)					
	All Girls	0.15 (-0.01-0.30)				0.11 (-0.07-0.28)
Academic Performance	Q1 (Ref)					
	Q2		-0.12 (-0.23--0.00)*		-0.13 (-0.25--0.02)*	-0.08 (-0.20-0.04)
	Q3		-0.15 (-0.28--0.01)*		-0.15 (-0.28--0.01)*	-0.08 (-0.22-0.07)
	Q4		-0.12 (-0.26-0.03)		-0.13 (-0.28-0.01)	-0.05 (-0.21-0.10)
Unauthorised absence	Q1 (lowest: Ref)					
	Q2		0.02 (-0.07-0.10)		0.04 (-0.05-0.13)	0.05 (-0.04-0.14)
	Q3		0.03 (-0.07-0.13)		0.05 (-0.05-0.14)	0.05 (-0.04-0.15)
	Q4		0.03 (-0.08-0.14)		0.04 (-0.06-0.15)	0.06 (-0.05-0.17)
Ethnic Density*	White UK Q1,2,3 (ref)					
	White UK Q4			-0.23 (-0.60-0.15)	-0.24 (-0.62-0.13)	-0.20 (-0.56-0.17)
	Black Caribbean Q1,2,3					
	Black Caribbean Q4			-0.12 (-0.26-0.01)	-0.13 (-0.26-0.01)	-0.13 (-0.27-0.00)
	Nigerian/Ghanaian Q1,2,3					
	Nigerian/Ghanaian Q4			-0.11 (-0.28-0.06)	-0.12 (-0.29-0.05)	-0.14 (-0.31-0.03)
	Other African Q1,2,3					
	Other African Q4			0.10 (-0.08-0.29)	0.10 (-0.09-0.29)	0.08 (-0.11-0.27)
	Indian Q1,2,3					

Indian Q4			-0.07 (-0.37-0.23)	-0.11 (-0.41-0.19)	-0.07 (-0.36-0.23)
Pak/Bang Q1,2,3					
Pak/Bang Q4			0.37 (0.08-0.67)*	0.38 (0.08-0.67)*	0.37 (0.07-0.67)*

*Significantly different to reference category ($p<0.05$)

Table 8.6 Girls: Waist SDS multivariate models

(Models 7-11 in next table)

		Model 1 - SES	Model 2 - Acculturation	Model 3 - Pupils' behaviour	Model 4 - Parental behaviour	Model 5 - Neighbourhood subjective	Model 6 - Neighbourhood objective
Standard of living	Q1(ref)						
	Q2	-0.01 (-0.12-0.10)	-0.01 (-0.12-0.09)	-0.01 (-0.12-0.10)	-0.01 (-0.12-0.10)	-0.01 (-0.12-0.10)	-0.01 (-0.12-0.10)
	Q3	-0.00 (-0.11-0.10)	-0.01 (-0.11-0.10)	-0.00 (-0.11-0.10)	-0.01 (-0.12-0.09)	-0.01 (-0.12-0.09)	-0.02 (-0.12-0.09)
	Q4	-0.02 (-0.15-0.11)	-0.02 (-0.15-0.11)	-0.01 (-0.14-0.12)	-0.02 (-0.16-0.11)	-0.03 (-0.16-0.11)	-0.04 (-0.17-0.09)
Family type & employment	2 parent, working (ref)						
	1 parent, working	0.02 (-0.10-0.14)	0.02 (-0.10-0.14)	0.02 (-0.10-0.14)	-0.04 (-0.24-0.16)	-0.04 (-0.24-0.16)	-0.04 (-0.24-0.16)
	2 parent, not working	0.01 (-0.16-0.18)	0.01 (-0.16-0.18)	0.02 (-0.15-0.19)	0.02 (-0.15-0.19)	0.02 (-0.15-0.19)	0.01 (-0.16-0.18)
	1 parent, not working	0.06 (-0.08-0.20)	0.06 (-0.08-0.20)	0.06 (-0.08-0.20)	0.01 (-0.21-0.23)	0.01 (-0.21-0.23)	0.01 (-0.21-0.22)
	Other structure	0.16 (-0.11-0.43)	0.16 (-0.11-0.43)	0.18 (-0.09-0.45)			
Generational status	Born in UK (ref)						
	<10yrs in UK		0.03 (-0.15-0.20)	0.04 (-0.14-0.21)	0.03 (-0.14-0.20)	0.03 (-0.14-0.20)	0.04 (-0.14-0.21)
Friend's of different ethnicity	Quite a lot (ref)						
	Most or all		0.09 (-0.02-0.21)	0.08 (-0.04-0.19)	0.08 (-0.04-0.20)	0.08 (-0.04-0.19)	0.08 (-0.04-0.19)
	Some or none		-0.00 (-0.08-0.07)	0.00 (-0.07-0.08)	0.01 (-0.07-0.08)	0.00 (-0.07-0.08)	0.00 (-0.07-0.08)
Fruit and Veg	>= 5 per day (Ref)						
	1-4 per day						
	<1 per day			-0.03 (-0.12-0.06)	-0.04 (-0.12-0.05)	-0.04 (-0.12-0.05)	-0.04 (-0.12-0.05)
				-0.07 (-0.17-0.03)	-0.08 (-0.18-0.02)	-0.08 (-0.18-0.02)	-0.08 (-0.18-0.02)
Eat Breakfast	Everyday (ref)						
	Not everyday			0.27 (0.14-0.39)	0.25 (0.12-0.37)*	0.25 (0.12-0.37)*	0.25 (0.12-0.37)
Activity sessions	Q1 (ref)						
	Q2			0.00 (-0.09-0.10)	0.00 (-0.09-0.10)	0.01 (-0.09-0.10)	0.01 (-0.09-0.10)
	Q3			0.07 (-0.02-0.17)	0.07 (-0.02-0.17)	0.07 (-0.03-0.16)	0.07 (-0.03-0.16)
	Q4			0.12 (0.02-0.23)*	0.12 (0.02-0.23)*	0.12 (0.02-0.23)*	0.12 (0.01-0.23)*

Smoking	Never tried (Ref)						
	Tried Once			-0.08 (-0.18-0.01)	-0.10 (-0.19--0.00)*	-0.10 (-0.19--0.00)*	-0.10 (-0.19--0.00)*
	Given-up			-0.13 (-0.31-0.06)	-0.14 (-0.32-0.05)	-0.13 (-0.32-0.05)	-0.13 (-0.32-0.06)
	Smoker			-0.01 (-0.16-0.14)	-0.03 (-0.18-0.12)	-0.03 (-0.18-0.12)	-0.03 (-0.18-0.12)
Mum overweight	No (ref)						
	Yes				0.22 (0.09-0.35)*	0.22 (0.09-0.35)*	0.22 (0.09-0.35)*
	Don't know				0.13 (-0.01-0.27)	0.13 (-0.01-0.27)	0.13 (-0.01-0.27)
Mum smoking	No (ref)						
	Yes				0.26 (0.11-0.41)*	0.26 (0.11-0.41)*	0.26 (0.11-0.41)*
Dad overweight	No (ref)						
	Yes				0.05 (-0.13-0.22)	0.04 (-0.13-0.21)	0.04 (-0.13-0.22)
	Don't know				0.01 (-0.17-0.18)	0.00 (-0.17-0.18)	0.00 (-0.17-0.18)
Dad smoking	No (ref)						
	Yes				-0.03 (-0.15-0.10)	-0.03 (-0.15-0.10)	-0.03 (-0.15-0.10)
Like Area	Agree (Ref)						
	Disagree					-0.02 (-0.12-0.09)	-0.01 (-0.12-0.09)
Safe Day	Agree (Ref)						
	Disagree					0.10 (-0.01-0.21)	0.10 (-0.01-0.21)
Safe night	Agree (Ref)						
	Disagree					-0.01 (-0.09-0.08)	-0.01 (-0.09-0.08)
Good area	Agree (Ref)						
	Disagree					-0.04 (-0.13-0.05)	-0.05 (-0.14-0.04)
IMD	Q1,2,3, 4 (Ref)						
	Q5						0.06 (-0.04-0.17)
Ethnic Density	White UK Q1,2,3 (ref)						
	White UK Q4						-0.00 (-0.30-0.29)
	Black Caribbean Q1,2,3						

Black Caribbean Q4						-0.06 (-0.30-0.17)
Nigerian/Ghanaian Q1,2,3						
Nig/Gha Q4						0.08 (-0.21-0.37)
Other African Q1,2,3						
Other African Q4						0.26 (-0.08-0.59)
Indian Q1,2,3						
Indian Q4						-0.05 (-0.43-0.33)
Pak/Bang Q1,2,3						
Pak/Bang Q4						0.45 (-0.00-0.91)

*Significantly different to reference category (p<0.05)

Table 9.5 (continued) Girls Waist SDS Models 7-11

		Model 7 - School sex and religion	Model 8 - School academic performance & absence	Model 9 - School ethnic density	Model 10 - academic performance, absence, ethnic density	Model 11 - academic performance, absence, ethnic density, sch sex rel
Standard of living	Q1(ref)					
	Q2	-0.01 (-0.12-0.10)	-0.00 (-0.11-0.11)	-0.01 (-0.12-0.10)	-0.00 (-0.11-0.11)	-0.00 (-0.11-0.11)
	Q3	-0.02 (-0.12-0.09)	-0.01 (-0.12-0.09)	-0.02 (-0.13-0.09)	-0.01 (-0.12-0.09)	-0.01 (-0.12-0.09)
	Q4	-0.04 (-0.17-0.10)	-0.04 (-0.17-0.10)	-0.04 (-0.17-0.09)	-0.04 (-0.17-0.10)	-0.04 (-0.17-0.10)
Family type & employment	2 parent, working (ref)					
	1 parent, working	-0.04 (-0.24-0.16)	-0.04 (-0.24-0.16)	-0.05 (-0.25-0.15)	-0.04 (-0.24-0.16)	-0.04 (-0.24-0.16)
	2 parent, not working	0.02 (-0.16-0.19)	-0.00 (-0.17-0.17)	-0.01 (-0.16-0.18)	-0.01 (-0.18-0.16)	-0.01 (-0.18-0.17)
	1 parent, not working	0.01 (-0.21-0.23)	0.01 (-0.21-0.23)	0.01 (-0.22-0.21)	-0.00 (-0.22-0.21)	0.00 (-0.21-0.22)
Generational status	Born in UK (ref)					
	<10yrs in UK	0.06 (-0.12-0.23)	0.04 (-0.14-0.21)	0.04 (-0.13-0.21)	0.04 (-0.13-0.22)	0.06 (-0.11-0.23)
Friend's of different ethnicity	Quite a lot (ref)					
	Most or all	0.08 (-0.04-0.19)	0.07 (-0.05-0.18)	0.07 (-0.04-0.19)	0.06 (-0.05-0.18)	0.07 (-0.05-0.18)
	Some or none	0.00 (-0.07-0.08)	0.01 (-0.07-0.08)	0.01 (-0.07-0.08)	0.01 (-0.07-0.09)	0.01 (-0.07-0.09)
Fruit and Veg	>= 5 per day (Ref)					
	1-4 per day	-0.04 (-0.13-0.05)	-0.04 (-0.12-0.05)	-0.04 (-0.13-0.05)	-0.04 (-0.12-0.05)	-0.04 (-0.12-0.05)
	<1 per day	-0.08 (-0.18-0.02)	-0.08 (-0.18-0.02)	-0.08 (-0.18-0.02)	-0.08 (-0.18-0.02)	-0.08 (-0.18-0.02)
Eat Breakfast	Everyday (ref)					
	Not everyday	0.25 (0.12-0.37)*	0.24 (0.12-0.37)*	0.25 (0.12-0.37)*	0.24 (0.12-0.37)*	0.24 (0.12-0.37)*
Activity sessions	Q1 (ref)					
	Q2	0.01 (-0.09-0.10)	0.00 (-0.09-0.10)	0.01 (-0.08-0.11)	0.01 (-0.08-0.11)	0.01 (-0.08-0.11)
	Q3	0.07 (-0.03-0.16)	0.07 (-0.03-0.16)	0.07 (-0.03-0.16)	0.07 (-0.03-0.16)	0.07 (-0.03-0.16)
	Q4	0.12 (0.01-0.23)*	0.12 (0.01-0.23)*	0.12 (0.01-0.23)*	0.12 (0.02-0.23)*	0.12 (0.02-0.23)*
Smoking	Never tried (Ref)					
	Tried Once	-0.10 (-0.19--0.00)*	-0.10 (-0.19--0.00)*	-0.09 (-0.19-0.00)	-0.09 (-0.19-0.00)	-0.09 (-0.18-0.01)
	Given-up	-0.13 (-0.31-0.06)	-0.14 (-0.32-0.05)	-0.12 (-0.31-0.06)	-0.13 (-0.32-0.06)	-0.13 (-0.31-0.06)

	Smoker	-0.03 (-0.18-0.12)	-0.03 (-0.18-0.12)	-0.03 (-0.18-0.12)	-0.03 (-0.18-0.12)	-0.03 (-0.18-0.12)
Mum overweight	No (ref)					
	Yes	0.22 (0.09-0.35)*	0.22 (0.09-0.35)*	0.21 (0.09-0.34)*	0.21 (0.09-0.34)*	0.22 (0.09-0.35)*
	Don't know	0.13 (-0.01-0.27)	0.13 (-0.01-0.27)	0.12 (-0.01-0.26)	0.12 (-0.02-0.26)	0.12 (-0.02-0.26)
	Not resident					
Mum smoking	No (ref)					
	Yes	0.26 (0.12-0.41)*	0.26 (0.11-0.41)*	0.26 (0.11-0.40)*	0.26 (0.11-0.40)*	0.25 (0.10-0.40)*
Dad overweight	No (ref)					
	Yes	0.04 (-0.13-0.21)	0.05 (-0.12-0.22)	0.04 (-0.13-0.21)	0.05 (-0.13-0.22)	0.05 (-0.13-0.22)
	Don't know	0.00 (-0.17-0.18)	0.00 (-0.17-0.18)	-0.00 (-0.18-0.17)	-0.00 (-0.18-0.17)	-0.00 (-0.18-0.17)
	Not resident					
Dad smoking	No (ref)					
	Yes	-0.03 (-0.15-0.10)	-0.02 (-0.15-0.10)	-0.02 (-0.15-0.10)	-0.02 (-0.14-0.11)	-0.02 (-0.14-0.11)
Like Area	Agree (Ref)					
	Disagree	-0.01 (-0.12-0.09)	-0.00 (-0.10-0.11)	-0.02 (-0.12-0.09)	-0.00 (-0.10-0.011)	-0.00 (-0.10-0.011)
Safe Day	Agree (Ref)					
	Disagree	0.10 (-0.01-0.21)	0.09 (-0.02-0.20)	0.10 (-0.01-0.21)	0.10 (-0.01-0.21)	0.10 (-0.01-0.21)
Safe night	Agree (Ref)					
	Disagree	-0.01 (-0.09-0.08)	-0.01 (-0.09-0.08)	-0.01 (-0.09-0.07)	-0.01 (-0.09-0.07)	-0.01 (-0.09-0.07)
Good area	Agree (Ref)					
	Disagree	-0.05 (-0.14-0.04)	-0.05 (-0.14-0.04)	-0.05 (-0.13-0.04)	-0.04 (-0.13-0.04)	-0.05 (-0.14-0.04)
IMD	Q1,2,3, 4 (Ref)					
	Q5	0.07 (-0.04-0.17)	0.07 (-0.03-0.17)	0.06 (-0.04-0.16)	0.07 (-0.03-0.17)	0.07 (-0.04-0.17)
Ethnic Density	White UK Q1,2,3 (ref)					
	White UK Q4	-0.02 (-0.28-0.31)	-0.02 (-0.31-0.27)	0.08 (-0.28-0.44)	0.08 (-0.28-0.45)	0.09 (-0.27-0.45)
	Black Caribbean Q1,2,3					
	Black Caribbean Q4	-0.06 (-0.30-0.18)	-0.07 (-0.30-0.17)	-0.04 (-0.28-0.20)	-0.04 (-0.28-0.20)	-0.03 (-0.27-0.21)
	Nigerian/Ghanaian Q1,2,3					
	Nig/Gha Q4	0.07 (-0.21-0.36)	0.08 (-0.21-0.37)	0.09 (-0.20-0.38)	0.09 (-0.20-0.38)	0.09 (-0.20-0.38)

	Other African Q1,2,3					
	Other African Q4	0.25 (-0.09-0.58)	0.27 (-0.07-0.61)	0.24 (-0.11-0.58)	0.24 (-0.11-0.58)	0.24 (-0.10-0.58)
	Indian Q1,2,3					
	Indian Q4	-0.04 (-0.42-0.34)	-0.04 (-0.42-0.34)	-0.03 (-0.42-0.35)	-0.02 (-0.40-0.37)	-0.01 (-0.40-0.38)
	Pak/Bang Q1,2,3					
	Pak/Bang Q4	0.46 (0.00-0.91)*	0.45 (0.00-0.91)*	0.37 (-0.10-0.84)	0.37 (-0.10-0.85)	0.38 (-0.10-0.85)
School religion	Non-denominational (Ref)					
	Church of England	-0.04 (-0.35-0.27)				0.04 (-0.27-0.35)
	Catholic	0.08 (-0.19-0.35)				0.17 (-0.10-0.45)
School sex	Mixed (Ref)					
	All Girls	0.18 (-0.04-0.41)				0.16 (-0.09-0.41)
Academic Performance	Q1 (Ref)					
	Q2		-0.17 (-0.34--0.00)*		-0.19 (-0.36--0.03)*	-0.12 (-0.30-0.07)
	Q3		-0.08 (-0.28-0.12)		-0.08 (-0.28-0.12)	0.01 (-0.21-0.23)
	Q4		-0.14 (-0.35-0.06)		-0.16 ~(-0.37-0.04)	-0.05 (-0.29-0.18)
Unauthorised absence	Q1 (lowest: Ref)					
	Q2		0.12 (-0.02-0.26)		0.14 (0.01-0.28)	0.16 (0.02-0.30)*
	Q3		0.14 (-0.01-0.29)		0.16 (0.01-0.31)	0.18 (0.02-0.33)*
	Q4		0.33 (0.16-0.49)*		0.35 (0.18-0.51)	0.36 (0.19-0.52)*
Ethnic Density*	White UK Q1,2,3 (Ref)					
	White UK Q4			-0.19 (-0.64-0.26)	-0.25 (-0.70-0.20)	-0.18 (-0.63-0.28)
	Black Caribbean Q1,2,3 (Ref)					
	Black Caribbean Q4			-0.25 (-0.45--0.04)*	-0.26 (-0.47--0.06)*	-0.27 (-0.47--0.07)*
	Nigerian/Ghanaian Q1,2,3 (Ref)					
	Nigerian/Ghanaian Q4			-0.09 (-0.35-0.17)	-0.11 (-0.37-0.15)	-0.12 (-0.38-0.14)
	Other African Q1,2,3 (Ref)					
	Other African Q4			0.11 (-0.18-0.39)	0.15 (-0.14-0.43)	0.12 (-0.16-0.41)
	Indian Q1,2,3 (Ref)					
	Indian Q4			-0.10 (-0.50-0.31)	-0.15 (-0.55-0.26)	-0.12 (-0.53-0.29)

Pak/Bang Q1,2,3 (Ref)					
Pak/Bang Q4			0.25 (-0.17-0.67)	0.26 (-0.16-0.68)	0.26 (-0.16-0.68)

*Significantly different to reference category (p<0.05)

Table 8.7 Boys: BMI SDS - ethnic differences relative to White UK by age

	11.5	12	12.5	13	13.5	14	14.5	15	15.5	16
Baseline										
White UK	0	0	0	0	0	0	0	0	0	0
Black Caribbean	0.02	0.06	0.11	0.15	0.2	0.24	0.29	0.33	0.37	0.42
	(-0.17-0.21)	(-0.12-0.25)	(-0.07-0.29)	(-0.02-0.33)	(0.02-0.37)*	(0.07-0.41)*	(0.11-0.46)*	(0.15-0.51)*	(0.19-0.56)*	(0.23-0.61)
Nigerian/Ghanaian	0	0.05	0.09	0.14	0.19	0.23	0.28	0.32	0.37	0.41
	(-0.23-0.24)	(-0.18-0.28)	(-0.13-0.31)	(-0.08-0.35)	(-0.03-0.40)	(0.02-0.44)	(0.06-0.49)*	(0.11-0.54)*	(0.15-0.59)*	(0.18-0.64)
Other African	-0.04	-0.04	-0.03	-0.03	-0.03	-0.02	-0.02	-0.01	-0.01	-0.01
	(-0.27-0.20)	(-0.26-0.19)	(-0.25-0.19)	(-0.24-0.18)	(-0.24-0.19)	(-0.23-0.19)	(-0.23-0.19)	(-0.23-0.20)	(-0.23-0.21)	(-0.23-0.22)
Indian	-0.21	-0.23	-0.25	-0.26	-0.28	-0.30	-0.32	-0.34	-0.36	-0.38
	(-0.43-0.02)	(-0.44--0.01)*	(-0.46--0.04)*	(-0.47--0.06)*	(-0.49--0.08)*	(-0.51--0.10)*	(-0.53--0.12)*	(-0.55--0.13)*	(-0.58--0.15)*	(-0.60--0.16)*
Pakistani/Bangladeshi	-0.10	-0.10	-0.09	-0.09	-0.09	-0.09	-0.08	-0.08	-0.08	-0.08
	(0.31-0.11)	(-0.30-0.10)	(-0.29-0.10)	(-0.28-0.10)	(-0.28-0.10)	(-0.27-0.10)	(-0.27-0.10)	(-0.27-0.11)	(-0.28-0.12)	(-0.28-0.13)
Final										
White UK	0	0	0	0	0	0	0	0	0	0
Black Caribbean	-0.06	-0.02	0.02	0.06	0.1	0.15	0.19	0.23	0.27	0.31
	(-0.27-0.14)	(0.22-0.18)	(-0.17-0.22)	(-0.13-0.26)	(-0.09-0.30)	(-0.04-0.34)	(-0.00-0.38)	(0.03-0.43)*	(0.07-0.47)*	(0.11-0.52)*
Nigerian/Ghanaian	-0.05	0	0.04	0.08	0.13	0.17	0.21	0.25	0.3	0.34
	(-0.31-0.22)	(-0.26-0.25)	(-0.21-0.29)	(-0.16-0.33)	(-0.11-0.37)	(-0.07-0.41)	(-0.03-0.45)	(0.01-0.50)*	(0.05-0.55)*	(0.08-0.60)*
Other African	-0.12	-0.13	-0.13	-0.13	-0.14	-0.14	-0.15	-0.15	-0.15	-0.16
	(-0.39-0.14)	(-0.38-0.13)	(-0.38-0.12)	(-0.38-0.11)	(-0.38-0.11)	(-0.39-0.10)	(-0.39-0.10)	(0.40-0.10)	(-0.41-0.10)	(-0.42-0.10)
Indian	-0.18	-0.21	-0.23	-0.26	-0.28	-0.31	-0.33	-0.36	-0.38	-0.41
	(-0.43-0.07)	(-0.44-0.03)	(-0.46-0.00)	(-0.49--0.03)*	(-0.51--0.05)*	(-0.53--0.08)*	(-0.56--0.10)*	(-0.59-0.13)*	(-0.62--0.15)*	(-0.65--0.17)*
Pakistani/Bangladeshi	-0.05	-0.05	-0.05	-0.06	-0.06	-0.06	-0.07	-0.07	-0.07	-0.07
	(-0.27-0.18)	(-0.27-0.17)	(-0.27-0.16)	-0.27-0.15)	(-0.27-0.15)	(-0.27-0.14)	(-0.27-0.14)	(-0.28-0.14)	(-0.29-0.15)	(-0.30-0.06)

*Significantly different to White UK (p<0.05)

Table 8.8 Boys: Waist SDS - ethnic differences relative to White UK by age

	11.5	12	12.5	13	13.5	14	14.5	15	15.5	16
Baseline										
White UK	0	0	0	0	0	0	0	0	0	0
Black Caribbean	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
	(-0.29-0.10)	(-0.28-0.08)	(-0.26-0.07)	(-0.26-0.06)	(-0.25-0.06)	(-0.25-0.06)	(-0.25-0.06)	(-0.26-0.07)	(-0.27-0.08)	(-0.28-0.09)
Nigerian/Ghanaian	-0.4*	-0.35*	-0.30*	-0.25*	-0.20*	-0.16	-0.11	-0.06	-0.01	0.04
	(-0.64--0.16)	(-0.57--0.13)	(-0.51--0.09)	(-0.45--0.06)	(-0.40--0.01)	(-0.35-0.03)	(-0.30-0.08)	(-0.26-0.14)	(-0.22-0.20)	(-0.19-0.26)
Other African	-0.31*	-0.30*	-0.30*	-0.29*	-0.28*	-0.27*	-0.26*	-0.26*	-0.25*	-0.24*
	(-0.55--0.08)	(-0.52--0.09)	(-0.50--0.09)	(-0.48--0.09)	(-0.47--0.09)	(-0.46--0.09)	(-0.45--0.07)	(-0.45--0.06)	(-0.46--0.4)	(-0.46--0.02)
Indian	0.06	0.02	-0.01	-0.05	-0.09	-0.12	-0.16	-0.19	-0.23*	-0.27*
	(-0.17-0.28)	(-0.19-0.23)	(-0.21-0.19)	(-0.24-0.14)	(-0.27-0.10)	(-0.31-0.06)	(-0.35-0.03)	(-0.39-0.00)	(-0.44--0.02)	(-0.49--0.05)
Pakistani/Bangladeshi	-0.14	-0.13	-0.12	-0.11	-0.1	-0.08	-0.07	-0.06	-0.05	-0.04
	(-0.35-0.07)	(-0.32-0.07)	(-0.30-0.07)	(-0.28-0.07)	(-0.27-0.08)	(-0.26-0.09)	(-0.25-0.10)	(-0.24-0.12)	(-0.24-0.14)	(-0.24-0.17)
Final										
White UK	0	0	0	0	0	0	0	0	0	0
Black Caribbean	-0.19	-0.19	-0.19*	-0.19*	-0.19*	-0.19*	-0.19*	-0.18	-0.18	-0.18
	(-0.41-0.02)	(-0.39-0.01)	(-0.38--0.00)	(-0.37--0.01)	(-0.37--0.01)	(-0.37--0.01)	(-0.37--0.00)	(-0.37-0.00)	(-0.38-0.02)	(-0.39-0.03)
Nigerian/Ghanaian	-0.44*	-0.39*	-0.34*	-0.30*	-0.25*	-0.20	-0.15	-0.11	-0.06	-0.01
	(-0.71--0.17)	(-0.65--0.14)	(-0.59--0.10)	(-0.53--0.07)	(-0.48--0.02)	(-0.43-0.02)	(-0.38-0.07)	(-0.34-0.13)	(-0.31-0.19)	(-0.27-0.25)
Other African	-0.41*	-0.41*	-0.4*	-0.40*	-0.39*	-0.38*	-0.38*	-0.37*	-0.37*	-0.36*
	(-0.68--0.14)	(-0.66--0.15)	(-0.65--0.16)	(-0.63--0.16)	(-0.62--0.16)	(-0.61--0.15)	(-0.61--0.14)	(-0.61--0.13)	(-0.61--0.12)	(-0.62--0.10)
Indian	0.03	-0.01	-0.05	-0.10	-0.14	-0.18	-0.22	-0.26*	-0.30*	-0.34*
	(-0.23-0.28)	(-0.25-0.23)	(-0.28-0.17)	(-0.32-0.13)	(-0.35-0.08)	(-0.39-0.04)	(-0.44-0.00)	(-0.48--0.03)	(-0.53--0.06)	(-0.59--0.09)
Pakistani/Bangladeshi	-0.12	-0.12	-0.11	-0.11	-0.11	-0.10	-0.10	-0.10	-0.09	-0.10
	(-0.36-0.11)	(-0.34-0.11)	(-0.32-0.10)	(-0.31-0.09)	(-0.31-0.09)	(-0.30-0.10)	(-0.30-0.10)	(-0.30-0.11)	(-0.31-0.13)	(-0.32-0.14)

*Significantly different to White UK ($p<0.05$)

Table 8.9 Girls: BMI SDS - ethnic differences relative to White UK by age

	11.5	12	12.5	13	13.5	14	14.5	15	15.5	16
Baseline										
White UK	0	0	0	0	0	0	0	0	0	0
Black Caribbean	0.31*	0.33*	0.34*	0.35*	0.37*	0.38*	0.39*	0.41*	0.42*	0.44*
	(0.12-0.50)	(0.14-0.51)	(0.16-0.52)	(0.18-0.53)	(0.19-0.54)	(0.21-0.55)	(0.22-0.57)	(0.23-0.59)	(0.24-0.60)	(0.25-0.62)
Nigerian/Ghanaian	0.25	0.27*	0.30*	0.32*	0.35*	0.38*	0.40*	0.43*	0.45*	0.48*
	(0.04-0.46)*	(0.07-0.48)	(0.10-0.50)	(0.13-0.52)	(0.16-0.54)	(0.19-0.56)	(0.21-0.59)	(0.23-0.62)	(0.25-0.65)	(0.27-0.68)
Other African	0.24*	0.25*	0.26*	0.27*	0.28*	0.29*	0.30*	0.30*	0.31*	0.32*
	(0.00-0.48)	(0.02-0.48)	(0.03-0.49)	(0.05-0.49)	(0.06-0.50)	(0.07-0.50)	(0.08-0.51)	(0.08-0.53)	(0.09-0.54)	(0.09-0.55)
Indian	-0.08	-0.09	-0.10	-0.11	-0.12	-0.13	-0.14	-0.15	-0.16	-0.17
	(-0.32-0.16)	(-0.32-0.14)	(-0.33-0.13)	(-0.33-0.11)	(-0.34-0.10)	(-0.35-0.09)	(-0.36-0.08)	(-0.37-0.08)	(-0.39-0.07)	(-0.41-0.07)
Pakistani/Bangladeshi	-0.13	-0.13	-0.12	-0.12	-0.11	-0.11	-0.10	-0.10	-0.09	-0.09
	(-0.39-0.13)	(-0.38-0.13)	(-0.37-0.13)	(-0.36-0.13)	(-0.35-0.13)	(-0.35-0.13)	(-0.34-0.14)	(-0.34-0.15)	(-0.35-0.16)	(-0.35-0.17)
Final										
White UK	0	0	0	0	0	0	0	0	0	0
Black Caribbean	0.27*	0.28*	0.29*	0.31*	0.32*	0.33*	0.34*	0.36*	0.37*	0.38*
	(0.05-0.48)	(0.07-0.49)	(0.09-0.50)	(0.11-0.51)	(0.12-0.52)	(0.13-0.53)	(0.15-0.54)	(0.16-0.56)	(0.16-0.57)	(0.17-0.59)
Nigerian/Ghanaian	0.06	0.09	0.12	0.15	0.18	0.21	0.24*	0.27*	0.3*	0.32*
	(-0.18-0.30)	(-0.15-0.32)	(-0.11-0.35)	(-0.08-0.37)	(-0.05-0.40)	(-0.02-0.43)	(0.01-0.46)	(0.04-0.49)	(0.06-0.53)	(0.09-0.56)
Other African	0.07	0.08	0.08	0.09	0.10	0.10	0.11	0.12	0.12	0.13
	(-0.20-0.34)	(-0.19-0.34)	(-0.18-0.34)	(-0.17-0.35)	(-0.16-0.35)	(-0.15-0.36)	(-0.15-0.37)	(-0.14-0.38)	(-0.14-0.39)	(-0.14-0.40)
Indian	-0.02	-0.03	-0.04	-0.06	-0.07	-0.09	-0.10	-0.11	-0.13	-0.14
	(-0.29-0.25)	(-0.29-0.23)	(-0.30-0.21)	(-0.31-0.19)	(-0.32-0.18)	(-0.33-0.16)	(-0.35-0.15)	(-0.37-0.14)	(-0.39-0.13)	(-0.41-0.13)
Pakistani/Bangladeshi	-0.30*	-0.29*	-0.28*	-0.28*	-0.27	-0.26	-0.25	-0.25	-0.24	-0.23
	(-0.59--0.01)	(-0.58--0.01)	(-0.56--0.01)	(-0.55--0.00)	(-0.54-0.00)	(-0.53-0.01)	(0.53-0.02)	(-0.53-0.03)	(-0.52-0.04)	(-0.53-0.06)

*Significantly different to White UK ($p<0.05$)

Table 8.10 Girls: Waist SDS - ethnic differences relative to White UK by age

	11.5	12	12.5	13	13.5	14	14.5	15	15.5	16
Baseline										
White UK	0	0	0	0	0	0	0	0	0	0
Black Caribbean	-0.17	0	0.13	0.21*	0.26*	0.26*	0.21*	0.13	0	-0.17
	(-0.45-0.11)	(-0.22-0.22)	(-0.07-0.32)	(0.02-0.41)	(0.06-0.46)	(0.06-0.46)	(0.02-0.41)	(-0.06-0.32)	(-0.20-0.20)	(-0.40-0.07)
Nigerian/Ghanaian	0.01	0.10	0.17	0.21	0.24*	0.24*	0.23*	0.19	0.13	0.06
	(-0.28-0.31)	(-0.14-0.34)	(-0.05-0.38)	(-0.00-0.43)	(0.02-0.46)	(0.02-0.46)	(0.01-0.44)	(-0.02-0.40)	(-0.08-0.35)	(-0.20-0.31)
Other African	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.10
	(-0.26-0.42)	(-0.19-0.35)	(-0.16-0.32)	(-0.16-0.32)	(-0.17-0.33)	(-0.17-0.33)	(-0.16-0.33)	(-0.15-0.33)	(-0.15-0.34)	(-0.19-0.39)
Indian	0.13	0.04	-0.05	-0.12	-0.18	-0.23	-0.26*	-0.28*	-0.29*	-0.29
	(-0.20-0.47)	(-0.23-0.30)	(-0.29-0.19)	(-0.37-0.12)	(-0.44-0.07)	(-0.49-0.03)	(-0.52--0.01)	(-0.53--0.04)	(-0.55--0.04)	(-0.59-0.02)
Pakistani/Bangladeshi	-0.23	-0.15	-0.1	-0.07	-0.06	-0.08	-0.13	-0.20	-0.30*	-0.43*
	(-0.60-0.13)	(-0.44-0.14)	(-0.36-0.17)	(-0.33-0.20)	(-0.34-0.21)	(-0.36-0.19)	(-0.40-0.14)	(-0.47-0.06)	(-0.58--0.02)	(-0.76--0.10)
Final										
White UK	0	0	0	0	0	0	0	0	0	0
Black Caribbean	-0.17	0.01	0.14	0.22	0.27*	0.27*	0.23*	0.15	0.02	-0.14
	(-0.48-0.14)	(-0.25-0.26)	(-0.09-0.37)	(-0.00-0.45)	(0.04-0.50)	(0.04-0.51)	(0.00-0.46)	(-0.08-0.38)	(-0.21-0.26)	(-0.41-0.13)
Nigerian/Ghanaian	-0.02	0.07	0.14	0.20	0.23	0.24	0.23	0.20	0.15	0.07
	(-0.35-0.31)	(-0.20-0.34)	(-0.11-0.40)	(-0.06-0.45)	(-0.03-0.49)	(-0.02-0.50)	(-0.03-0.49)	(-0.06-0.45)	(-0.12-0.41)	(-0.23-0.38)
Other African	-0.04	-0.05	-0.06	-0.06	-0.06	-0.06	-0.06	-0.05	-0.04	-0.03
	(-0.43-0.34)	(-0.37-0.26)	(-0.35-0.23)	(-0.36-0.23)	(-0.36-0.24)	(-0.37-0.24)	(-0.36-0.24)	(-0.35-25)	(-0.35-0.27)	(-0.37-0.32)
Indian	0.28	0.18	0.09	0.01	-0.05	-0.11	-0.15	-0.18	-0.20	-0.20
	(-0.10-0.66)	(-0.13-0.50)	(-0.20-0.38)	(-0.28-0.30)	(-0.35-0.24)	(-0.40-0.19)	(-0.44-0.14)	(-0.47-0.11)	(-0.50-0.10)	(-0.55-0.14)
Pakistani/Bangladeshi	-0.39	-0.31	-0.25	-0.22	-0.21	-0.23	-0.28	-0.35*	-0.44*	-0.56*
	(-0.79-0.02)	(-0.64-0.03)	(-0.56-0.06)	(-0.53-0.09)	(-0.53-0.11)	(-0.56-0.09)	(-0.60-0.04)	(-0.66--0.04)	(-0.77--0.12)	(-0.94--0.18)

*Significantly different to White UK (p<0.05)

Table 8.11 Boys: Overweight/Obesity multivariate models

		Model 1 - SES	Model 2 - Acculturation	Model 3 - Pupils' behaviour	Model 4 - Parental behaviour	Model 6 - Neighbourhood	Model 8 - School (SES)
Standard of living	Q1(ref)						
	Q2	1.10 (0.64-1.90)	1.09 (0.63-1.88)	1.12 (0.64-1.96)	1.14 (0.65-2.00)	1.15 (0.65-2.03)	1.12 (0.63-1.98)
	Q3	1.17 (0.69-2.00)	1.18 (0.69-2.02)	1.19 (0.68-2.06)	1.15 (0.66-2.00)	1.14 (0.65-1.99)	1.10 (0.63-1.94)
	Q4	0.77 (0.40-1.50)	0.78 (0.40-1.53)	0.77 (0.39-1.53)	0.73 (0.37-1.45)	0.71 (0.36-1.44)	0.70 (0.35-1.42)
Family type & employment	2 parent, working (ref)						
	1 parent, working	0.78 (0.42-1.48)	0.78 (0.41-1.47)	0.79 (0.41-1.51)	0.59 (0.20-1.77)	0.59 (0.19-1.80)	0.59 (0.19-1.81)
	2 parent, not working	0.94 (0.41-2.17)	0.97 (0.42-2.23)	1.02 (0.44-2.40)	1.03 (0.44-2.40)	1.05 (0.44-2.49)	1.07 (0.45-2.53)
	1 parent, not working	1.43 (0.69-2.98)	1.44 (0.69-3.01)	1.32 (0.62-2.80)	0.99 (0.32-3.07)	1.02 (0.32-3.23)	0.99 (0.31-3.18)
Generational status	Born in UK (ref)						
	<10yrs in UK		0.95 (0.45-1.99)	1.08 (0.51-2.31)	1.08 (0.51-2.30)	1.07 (0.50-2.30)	1.06 (0.49-2.31)
Friend's of different ethnicity	Quite a lot (ref)						
	Most or all		1.25 (0.67-2.35)	1.23 (0.64-2.35)	1.20 (0.63-2.28)	1.21 (0.63-2.32)	1.22 (0.63-2.35)
	Some or none		0.83 (0.55-1.23)	0.85 (0.56-1.27)	0.86 (0.60-1.29)	0.84 (0.56-1.27)	0.84 (0.55-1.26)
Fruit and Veg	>= 5 per day (Ref)						
	1-4 per day			1.22 (0.78-1.91)	1.20 (0.77-1.88)	1.21 (0.77-1.90)	1.22 (0.77-1.92)
	<1 per day			0.66 (0.38-1.16)	0.65 (0.37-1.14)	0.66 (0.37-1.15)	0.64 (0.36-1.13)
Eat Breakfast	Everyday (ref)						
	Not everyday			3.89 (2.11-7.19)*	3.77 (2.05-6.95)*	3.87 (2.08-7.21)*	3.92 (2.10-7.32)*
Activity sessions	Q1 (least, ref)						
	Q2			0.55 (0.32-0.93)*	0.55 (0.32-0.93)*	0.55 (0.32-0.94)*	0.54 (0.31-0.92)*
	Q3			0.68 (0.40-1.17)	0.68 (0.40-1.17)	0.69 (0.40-1.19)	0.70 (0.40-1.21)
	Q4			0.85 (0.47-1.51)	0.78 (0.43-1.40)	0.80 (0.44-1.43)	0.81 (0.45-1.46)
Smoking	Never tried (Ref)						
	Tried Once			1.99 (1.20-3.29)*	1.94 (1.17-3.21)*	1.95 (1.17-3.24)*	2.00 (1.20-3.34)*
	Given-up			0.98 (0.32-3.02)	1.02 (0.33-3.14)	0.98 (0.32-3.07)	0.96 (0.31-3.00)
	Smoker			0.97 (0.38-2.47)	0.95 (0.37-2.41)	0.97 (0.38-2.50)	1.02 (0.39-2.65)
Mum overweight	No (ref)						
	Yes				2.03 (0.93-4.43)	2.04 (0.93-4.50)	2.07 (0.94-4.58)
	Don't know				1.06 (0.46-2.45)	1.07 (0.46-2.50)	1.07 (0.46-2.49)
Mum smoking	No (ref)						
	Yes				2.13 (1.00-4.57)	2.19 (1.01-4.75)*	2.12 (0.97-4.61)

Dad overweight	No (ref)						
	Yes				2.13 (0.89-5.08)	2.12 (0.88-5.11)	2.19 (0.91-5.32)
	Don't know				0.88 (0.34-2.31)	0.80 (0.30-2.14)	0.81 (0.31-2.16)
Dad smoking	No (ref)						
	Yes				0.93 (0.50-1.75)	1.21 (0.40-3.66)	0.94 (0.50-1.78)
Like Area	Agree (Ref)						
	Disagree					0.78 (0.42-1.45)	0.76 (0.41-1.43)
Safe Day	Agree (Ref)						
	Disagree					1.81 (0.95-3.43)	1.81 (0.95-3.45)
Safe night	Agree (Ref)						
	Disagree					1.08 (0.69-1.70)	1.08 (0.69-1.71)
Good area	Agree (Ref)						
	Disagree					0.92 (0.56-1.53)	0.93 (0.56-1.54)
IMD	Q1,2,3, 4 (Ref)						
	Q5					0.94 (0.55-1.60)	0.94 (0.55-1.61)
Ethnic Density	White UK Q1,2,3 (Ref)						
	White UK Q4					0.77 (0.23-2.67)	0.77 (0.22-2.71)
	Black Caribbean Q1,2,3 (Ref)						
	Black Caribbean Q4					2.69 (0.68-10.75)	2.54 (0.63-10.27)
	Nigerian/Ghanaian Q1,2,3 (Ref)						
	Nigerian/Ghanaian Q4					1.33 (0.18-9.68)	1.43 (0.19-10.59)
	Other African Q1,2,3 (Ref)						
	Other African Q4					3.37 (0.55-20.68)	3.25 (0.53-19.90)
	Indian Q1,2,3 (Ref)						
	Indian Q4					1.86 (0.30-11.41)	1.78 (0.27-11.06)
	Pak/Bang Q1,2,3 (Ref)						
	Pak/Bang Q4					0.36 (0.08-1.72)	0.35 (0.07-1.70)
Academic Performance	Q1 (Ref)						
	Q2						1.31 (0.52-3.32)
	Q3						1.84 (0.66-5.11)
	Q4						1.72 (0.64-4.62)
Unauthorised	Q1 (lowest: Ref)						

absence						
Q2						1.04 (0.59-1.84)
Q3						0.58 (0.31-1.11)
Q4						0.64 (0.31-1.33)

*Significantly different to reference category ($p<0.05$)

Table 8.12 Girls: Overweight/Obesity multivariate models

		Model 1 - SES	Model 2 - Acculturation	Model 3 - Pupils' behaviour	Model 4 - Parental behaviour	Model 6 - Neighbourhood	Model 12 - School (Type & ethnic density)
Standard of living	Q1(ref)						
	Q2	0.70 (0.36-1.38)	0.70 (0.36-1.38)	0.69 (0.35-1.39)	0.71 (0.35-1.43)	0.74 (0.36-1.51)	0.72 (0.34-1.53)
	Q3	1.43 (0.77-2.64)	1.43 (0.77-2.65)	1.42 (0.75-2.69)	1.43 (0.74-2.74)	1.46 (0.75-2.84)	1.52 (0.75-3.06)
	Q4	0.61 (0.28-1.32)	0.60 (0.27-1.33)	0.61 (0.27-1.37)	0.57 (0.25-1.33)	0.57 (0.24-1.34)	0.57 (0.23-1.41)
Family type & employment	2 parent, working (ref)						
	1 parent, working	1.26 (0.62-2.54)	1.26 (0.62-2.55)	1.34 (0.65-2.76)	0.96 (0.29-3.22)	1.03 (0.31-3.45)	0.96 (0.27-3.40)
	2 parent, not working	0.72 (0.24-2.13)	0.72 (0.24-1.13)	0.72 (0.24-2.23)	0.73 (0.23-2.32)	0.73 (0.23-2.32)	0.70 (0.20-2.41)
	1 parent, not working	0.97 (0.43-2.22)	0.97 (0.43-2.23)	0.98 (0.42-2.29)	0.74 (0.20-2.79)	0.80 (0.21-3.01)	0.74 (0.18-2.97)
Generational status	Born in UK (ref)						
	<10yrs in UK		0.99 (0.39-2.54)	1.06 (0.40-2.80)	0.99 (0.36-2.69)	1.06 (0.38-2.90)	1.50 (0.47-4.78)
Friend's of different ethnicity	Quite a lot (ref)						
	Most or all		0.96 (0.47-1.95)	0.93 (0.45-1.91)	0.95 (0.45-1.98)	0.95 (0.45-1.99)	0.97 (0.45-2.13)
	Some or none		1.05 (0.66-1.67)	1.06 (0.66-1.71)	1.13 (0.69-1.85)	1.10 (0.67-1.80)	1.19 (0.71-2.00)
Fruit and Veg	>= 5 per day (Ref)						
	1-4 per day			0.99 (0.58-1.71)	0.95 (0.54-1.66)	0.93 (0.53-1.64)	0.94 (0.52-1.69)
	<1 per day			0.43 (0.23-0.81)*	0.39 (0.20-0.74)*	0.38 (0.20-0.73)*	0.37 (0.19-0.74)*
Eat Breakfast	Everyday (ref)						
	Not everyday			5.78 (2.86-11.67)*	5.72 (2.77-11.81)*	5.91 (2.85-12.25)*	6.89 (3.12-15.22)*
Activity sessions	Q1 (least, ref)						
	Q2			1.66 (0.88-3.13)	1.76 (0.91-3.39)	1.74 (0.90-3.37)	1.89 (0.94-3.79)
	Q3			1.22 (0.67-2.22)	1.25 (0.68-2.31)	1.25 (0.67-2.31)	1.31 (0.69-2.50)
	Q4			1.15 (0.59-2.26)	1.12 (0.56-2.25)	1.08 (0.54-2.17)	1.12 (0.54-2.34)
Smoking	Never tried (Ref)						
	Tried Once			0.62 (0.34-1.12)	0.57 (0.31-1.06)	0.55 (0.29-1.02)	0.53 (0.27-1.01)
	Given-up			1.06 (0.32-3.48)	1.08 (0.32-3.63)	1.12 (0.33-3.78)	1.09 (0.31-3.84)
	Smoker			0.71 (0.27-1.91)	0.65 (0.23-1.82)	0.63 (0.22-1.76)	0.56 (0.19-1.68)
Mum overweight	No (ref)						
	Yes				3.58 (1.60-8.04)*	3.55 (1.58-7.99)*	4.02 (1.70-9.49)*
	Don't know				2.14 (0.90-5.10)	2.19 (0.92-5.21)	2.20 (0.88-5.48)
Mum smoking	No (ref)						
	Yes				1.98 (0.79-4.95)	2.04 (0.81-5.10)	2.15 (0.81-5.68)

Dad overweight	No (ref)						
	Yes				1.86 (0.65-5.33)	1.95 (0.67-5.66)	1.81 (0.59-5.52)
	Don't know				0.57 (0.19-1.74)	0.58 (0.19-1.77)	0.54 (0.16-1.74)
Dad smoking	No (ref)						
	Yes				0.91 (0.41-2.04)	0.92 (0.41-2.06)	0.93 (0.40-2.19)
Like Area	Agree (Ref)						
	Disagree					0.95 (0.47-1.92)	0.89 (0.42-1.86)
Safe Day	Agree (Ref)						
	Disagree					1.08 (0.53-2.20)	1.18 (0.56-2.48)
Safe night	Agree (Ref)						
	Disagree					1.03 (0.60-1.78)	1.04 (0.59-1.85)
Good area	Agree (Ref)						
	Disagree					0.79 (0.44-1.42)	0.79 (0.43-1.45)
IMD	Q1,2,3, 4 (Ref)						
	Q5					0.87 (0.46-1.63)	0.79 (0.38-1.67)
Ethnic Density	White UK Q1,2,3 (Ref)						
	White UK Q4					0.82 (0.18-3.68)	0.83 (0.42-1.61)
	Black Caribbean Q1,2,3 (Ref)						
	Black Caribbean Q4					0.22 (0.05-0.97)*	3.80 (0.43-33.74)
	Nigerian/Ghanaian Q1,2,3 (Ref)						
	Nig/Gha Q4					1.95 (0.30-12.54)	0.26 (0.05-1.29)
	Other African Q1,2,3 (Ref)						
	Other African Q4					10.34 (0.98-109.21)	10.19 (0.41-253.24)
	Indian Q1,2,3 (Ref)						
	Indian Q4					0.44 (0.06-3.17)	0.34 (0.04-2.94)
	Pak/Bang Q1,2,3 (Ref)						
	Pak/Bang Q4					3.38 (0.25-45.08)	3.58 (0.19-65.73)
School sex	Mixed (Ref)						
	All girls						1.53 (0.55-4.27)
School religion	Non-denominational (Ref)						
	Church of England						1.04 (0.24-4.40)
	Catholic						2.93 (0.75-11.45)

Ethnic Density***	White UK Q1,2,3 (Ref)						
	White UK Q4						0.13 (0.01-1.46)
	Black Caribbean Q1,2,3 (Ref)						
	Black Caribbean Q4						0.27 (0.09-0.84)*
	Nigerian/Ghanaian Q1,2,3 (Ref)						
	Black Caribbean Q4						0.53 (0.10-2.79)
	Other African Q1,2,3 (Ref)						
	Other African Q4						3.55 (0.53-23.68)
	Indian Q1,2,3 (Ref)						
	Indian Q4						5.03 (0.48-52.76)
	Pak/Bang Q1,2,3 (Ref)						
	Pak/Bang Q4						0.91 (0.08-10.13)

*Significantly different to reference category ($p<0.05$)

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