THE EFFECTS OF THE CHANGE! INTERVENTION ON CHILDREN'S PHYSICAL ACTIVITY AND HEALTH

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Statements

The presented research programme was part of a collaborative group project entitled CHANGE! (Children's Health, Activity and Nutrition: Get Educated!). The research had the full support of Wigan Council through the PSHE-C team, as well as the Primary Care Trust. Three strands of the project included nutrition, cardiometabolic health, and physical activity. This thesis presents results from the physical activity strand of the project, within which project design, data collection, and data analyses were solely conducted.

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Abstract

Low childhood physical activity levels, and high paediatric overweight and obesity levels, carry a considerable burden to health including cardiometabolic disease, low fitness, and reduced psychosocial well-being. Numerous school-based physical activity interventions have been conducted with varied success. This thesis therefore aimed to develop and investigate the effectiveness of the Children's Health, Activity and Nutrition: Get Educated! (CHANGE!) project, which was a school-based curriculum intervention to promote healthy lifestyles using an educational focus on physical activity and healthy eating.

The purpose of the formative study (Study 1) was to elicit subjective views of children, their parents, and teachers about physical activity to inform the design of the CHANGE! intervention programme. Analyses revealed that families have a powerful and important role in promoting health-enhancing behaviours. Involvement of parents and the whole family is a strategy that could be significant to increase children's physical activity levels.

There is large variation in the cut-points used to define moderate physical activity (MPA), vigorous physical activity (VPA) and sedentary time, which impacts on accurate estimation of physical activity levels. The purpose of Study 2 was to test a field-based protocol using intermittent activities representative of children's physical activity behaviours, to generate behaviourally valid, population-specific cut-points for sedentary behaviour, MPA and VPA. These

cut-points were subsequently applied to CHANGE! to investigate changes in physical activity (Study 3).

The CHANGE! intervention resulted in positive changes to body size and VPA outcomes after follow-up. The effects were strongest among those sociodemographic groups at greatest risk of poor health status. Further work is required to test the sustained effectiveness of this approach in the medium and long-term. Further, the development of an inexpensive and replicable field-based protocol to generate behaviourally valid and population-specific accelerometer cut-points may improve classification of physical activity levels in children, which could enhance subsequent intervention and observational studies.

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Glossary of Terms

Term	Thesis Definition
Adolescents	This term covers the chronological age range 12 to 17 years.
BMI	Body mass index, calculated using body mass and stature: BMI = body mass (kg) / stature^2 (m^2).
BMI SDS	Standardised BMI using z-scores.
Children	This term covers the chronological age range 4 to 11 years.
Moderate physical activity (MPA)	"[an] activity usually equivalent to brisk walking, which might be expected to leave the participant feeling warm and slightly out of breath" (Biddle et al., 1998, p. 2). Corresponds to energy expenditure between 3 and 6 metabolic equivalents (METS; Freedson et al., 1998).
Moderate-to-vigorous physical activity (MVPA)	Physical activity of at least moderate intensity that encompasses bouts of vigorous physical activity (VPA). Equivalent or greater than moderate intensity (≥ 3 METS). Results in increasing heart rate, sweating and breathing harder, or being out of breath, including, for example, brisk walking, skating or bike riding (NICE, 2009).

Pen profiles	An appropriate means for representing qualitative analysis outcomes from large data sets via a diagram of composite key emergent themes (Knowles, 2009).
Primary school	Attended by children 4 to 11 years of age in the United Kingdom. Comprised of infant and junior school children (Years 1 - 6).
Physical activity	Defined as "any bodily movement produced by skeletal muscles resulting in energy expenditure above resting" (Caspersen et al., 1985, p. 126).
Vigorous physical activity	"[an] activity usually equivalent to at least slow jogging, which might be expected to leave the participant out of breath and sweaty" (Biddle et al., 1998, p. 2). Corresponds to energy expenditure between 6 and 9 METS (Freedson et al., 1998).
YPAPM	Youth Physical Activity Promotion Model (Welk, 1999).

Chapter 1

Introduction

Introduction

1.1: The Research Problem

Physical activity, a behaviour, is defined as any bodily movement produced by skeletal muscles which results in energy expenditure above resting (Caspersen et al., 1985; Thompson et al., 2003). The promotion of physical activity has become a critical public health priority (Mountjoy et al., 2011), since regular participation in appropriate amounts and intensity confers benefits to children's physiological and psychological health (Department of Health, 2011; Strong et al., 2005). While Riddoch and Boreham (2000) advocate that there is little evidence directly relating childhood physical activity levels to adult health, research suggests that daily physical activity during childhood and adolescence can benefit adult cardiovascular fitness (Kemper et al., 2001). Further, a decrease in physical activity between early adolescence and adulthood is related to unhealthy cholesterol levels (Twisk et al., 2002) and a negative relationship exists between clustering of cardiovascular risk factors and physical activity (Andersen et al., 2006). Current scientific literature has found a close association between low physical activity levels and metabolic syndrome in children (Janssen and Leblanc, 2010; Pan and Pratt, 2008; Rizzo et al., 2007). More specifically, a recent statement on the health and fitness of young people suggested that low levels of physical activity are associated with higher levels of obesity, hypertension and cardiovascular risk factors, including increased instances of metabolic syndrome (Mountjoy et al., 2011). Further, physical activity during the growing years is important for the physical growth and development of children (Hills et al., 2007) and can improve health-related fitness (Sallis and Owen, 1999), have beneficial effects on psychological well-being (Biddle and Mutrie, 2008), and promote moral reasoning, positive self-concepts, and social interaction skills (Bunker, 1998).

Much concern has been expressed that considerable numbers of children do not engage in enough sustained physical activity to accrue such aforementioned health benefits (Biddle et al., 2004; Riddoch et al., 2007). The most recent physical activity guidelines propose that children and young people should undertake a range of moderate-to-vigorous activities, for at least 60 minutes each day (Department of Health, 2011). Current evidence suggests that young people are not meeting guidelines and that sedentary lifestyles remain a problem (Hills et al., 2011; Muller-Riemenschneider et al., 2008; Riddoch et al., 2007), though the interpretation of physical activity levels depends on how physical activity is defined and conceptualised (Jago et al., 2007; Sleap and Tolfrey, 2001). Nationally representative self-report data suggest that approximately 30% of boys and 40% of girls in the United Kingdom (UK) fail to meet these guidelines (The Information Centre, 2008). Other studies employing more stringent physical activity assessment methods have reported that children's physical activity levels are even lower, with one investigation observing that only 5.1% of boys and 0.4% of girls met current internationally recognised recommendations (Riddoch et al., 2007). Safety concerns, the restriction of physical activity opportunities and an advancement in technology enhancing sedentary leisure pursuits, including television viewing and computer games, have been advocated as contributing factors (Biddle et al., 1998; Strong et al., 2005). Current physical activity guidelines state that all children and young people (ages 5 – 18 years) should minimise the amount of time spent being sedentary for extended periods (Department of Health, 2011). Sedentary behaviour has been described as a modifiable risk factor for lifestyle related diseases, and that reducing sedentary behaviour to less than two hours a day can benefit physical activity and health (Gortmaker et al., 1996; Strong et al., 2005).

Obesity and other hypokinetic conditions (Allender et al., 2007) are associated with physical inactivity, which is the leading cause of morbidity (WHO, 2006). Despite evidence to suggest that the prevalence of obesity has plateaued in recent years (Lissner et al., 2010; Rokholm et al., 2010), and specifically in the UK (Boddy et al., 2010), previous stable phases have been followed by further increases, and prevalence of obesity remains extremely high (Cali and Caprio, 2008). If these trends are to be reversed, there is an urgent need to implement and evaluate healthy lifestyle promoting initiatives for children (Biddle and Mutrie, 2008). Since cardiovascular disease (CVD) has its origins in childhood, it seems intuitive that physical activity promotion may induce a more favourable risk profile and benefit future health. There is therefore need to identify contexts that can promote physically active behaviours to children that may benefit child health and potentially reduce the clustering of cardiovascular risk factors (Andersen et al., 2006).

Evidence suggests that population-based public health approaches are more effective and easier to implement than more selective, risk factor based approaches (Harrell et al., 1999). The school has been identified as a key setting for health promotion and an influential mechanism to engage children in physical activity (Brown and Summerbell, 2009), reaching a large number of children from diverse socio-economic backgrounds (Fox et al., 2004). Schools represent an important part of children's lives, providing an opportunity to improve the quality and quantity of health and well-being information given to children and their families (NICE, 2009; Naylor and McKay, 2009). Schools also have personnel who, with sufficient training and enthusiasm, can design and deliver effective physical activity interventions, establish and enforce healthy lifestyle policies, and serve as powerful role models for students (Wechsler et al., 2000). The traditional setting for physical activity promotion within schools is physical education (PE; Wechsler et al., 2000), yet concern has been expressed that PE alone is unlikely to provide sufficient activity to significantly benefit health (Biddle et al., 2004). An alternative but complementary school setting to PE for children is Personal and Social Health Education (PSHE). Indeed, PSHE presents one of the few opportunities that children can learn about healthy lifestyles and behaviour change. Such interventions can be easily integrated into the daily routine of schools and can be an effective means to increase the physical activity levels of children, both in school and at home (Siegrist et al., 2011).

Researchers have advocated that well-designed and well-implemented school-based programs can improve the physical activity and health of children (Naylor et al., 2006; Reed et al., 2008; Verstraete et al., 2007). Physical activity interventions within schools have been conducted successfully to increase the proportion of time children spend in moderate-to-vigorous physical activity (MVPA; Fitzgibbon et al., 2011; Gorely et al., 2009b; Magnusson et al., 2011). This said, interventions typically describe varied levels of success (Dobbins et al., 2009; Summerbell et al., 2005). A recent meta-analysis (Harris et al., 2009) found that although school-based physical activity interventions did not improve body mass index (BMI) they had other beneficial health effects. Conversely, Lavelle et al. (2012) found growing evidence that school-based interventions containing a physical activity component may be effective in helping to reduce BMI in children. The majority of primary school-based interventions have been conducted in the USA (Eisenmann et al., 2011; Erwin et al., 2011; Gortmaker et al., 1999b; Jago et al., 2011; Slawta et al., 2006; Tucker et al., 2011). Although examples of primary school interventions in other European countries exist, such as Germany (Siegrist et al., 2011), Ireland (Harrison et al., 2006), and Belgium (Verstraete et al., 2007), an evidence base in the UK is warranted due to cultural and educational differences inhibiting simple translocation of successful interventions from elsewhere (Timperio et al., 2004; Verstraete et al., 2007). Within the UK itself there is limited evidence from primary school-based interventions (Gorely et al., 2011; Gorely et al., 2009b; Kipping et al., 2008; Sahota et al., 2001a; Sahota et al., 2001b; Warren et al., 2003). The GreatFun2Run school-based healthy lifestyle intervention aimed to increase children's physical activity levels through teaching the skill of running via PE lessons, highlighting running and walking events, and through a range of classroom activities encouraging children to reflect on their activity levels (Gorely et al., 2009b). Intervention children increased their MVPA in comparison to Control children (Gorely et al., 2009b), but this effect was not maintained after 20 months follow-up (Gorely et al., 2011). Similarly, Kipping et al. (2008) employed a curriculum-based intervention, but found no statistically significant differences in BMI between Control and Intervention children. A physical activity curriculum delivered over lunchtime found improvements in self-reported and parent reported physical activity (Warren et al., 2003). Employing a whole school approach, targeting teacher training, playground activities and environmental changes, the APPLES trial found no differences in physical activity between Control and Intervention children (Sahota et al., 2001a; Sahota et al., 2001b).

Although the characteristics of successful primary school-based interventions are not obviously and consistently different from unsuccessful interventions (Doak et al., 2006; Flodmark et al., 2006), those that focus beyond just the classroom curriculum are more effective (Salmon et al., 2007). Specifically, a review of physical activity interventions for children concluded that interventions incorporating both school and family-based components could successfully increase at least some aspects of children's physical activity (Salmon et al., 2007). Moreover, systematic reviews have suggested that combined school-based physical activity and nutrition interventions may help to prevent children becoming overweight in the long-term (Brown and Summerbell, 2009), and are more likely to be effective when nutritional and physical activity behaviours are reinforced through a family intervention component (van Sluijs et al., 2007). The parental component has involved newsletters or homework assignments to be completed with parents.

Contradictory intervention findings are often reported as a result of methodological inconsistency, such as not incorporating objective measurements of physical activity (Mountjoy et al., 2011). The use of self-report and parental proxy measures, of unknown reliability and validity, to assess physical activity is a significant limitation of published intervention work. Such measures may not be sensitive enough to detect change (Timperio et al., 2004) and are not recommended for use with children under the age of 10, due to cognitive limitations (Foley et al., 2012). For this reason, electronic monitoring, such as accelerometry or pedometry, has been advised (Kohl et al., 2001). A further limitation is that changes in overall physical activity have not always been assessed (Salmon et al., 2007; van Sluijs et al., 2007) and a variety of accelerometer cut-points have been employed (Jago et al., 2007). Therefore, there is a need for empirical research to establish how a curriculum-based physical activity promoting intervention in the UK can impact children's physical activity and health.

1.2: Conceptual Framework: Green et al.'s (1980) Precede-Proceed Model and Welk's (1999) Youth Physical Activity Promotion Model

Behaviour change can often be complex to achieve and maintain. In order to develop a successful physical activity-based intervention, an appropriate conceptual health promotion model should be utilised to prioritise the key assets of the target group (NICE, 2007). A conceptual model ideally serving the needs of the intervention developed in this thesis is Green et al.'s (1980) Precede-Proceed model (Figure 1.1), which provides a comprehensive structured assessment of health and health needs, through the design and implementation of health promotion programmes to meet those emerging needs. The Precede-Proceed model has been considered to be the best among 10 planning models on usefulness for research and practice (Linnan et al., 2005) and could therefore potentially increase the sustainability of an intervention. PRECEDE (**P**redisposing, **R**einforcing, and **E**nabling **C**onstructs in

Educational **D**iagnosis and **E**valuation) outlines an indicative planning process to assist in the development of targeted and focused health programmes, whilst PROCEED (**P**olicy, **R**egulatory and **O**rganisational **C**onstructs in **E**ducational and **E**nvironmental **D**evelopment) aids in the implementation and evaluation of programmes. The last step accommodates intervention planning based on available resources and potential barriers. There are nine key phases in the model, five for assessment, one for implementation, and three related to evaluation. This thesis utilises the first six phases for developing and implementing the Children's Health, Activity and Nutrition: Get Educated! (CHANGE!) intervention.

An advantage of the Precede-Proceed framework is that it accepts multiple theoretical perspectives and it employs a 'bottom-up' approach in which a specific population's characteristics and needs are fully determined prior to programme development (Welk, 1999). Within this model emphasis is placed on the proposition that health and risks to health are caused by multiple factors, and it is for this reason efforts to effect behaviour and environmental change must also be multidimensional (Green et al., 1980). The Precede-Proceed model allows for participation of primary school children and their families in the process so that they can determine their behaviour and health outcomes by voluntary active involvement (Green et al., 1980). By involving the target population to assess their own needs and barriers, the participants' compliance to a tailored intervention programme is more likely to be successful and sustainable (Cole and Horacek, 2009; Lean et al., 2007).

Figure 1.1. Precede-Proceed Model (Green et al., 1980)

Factors that are associated with participation in physical activity are typically referred to as the study of physical activity determinants or correlates (Biddle et al., 2004). Correlates will be used from this point on, as many correlates may not be true determinants, as studies often show associations yet are unable to conclude causality (NICE, 2007). Physical activity is a complex behaviour, influenced by a number of correlates, which affect the frequency, intensity, duration and type of children's activity (Sallis and Patrick, 1994). Identification of modifiable correlates and a comprehensive understanding of the influence of these factors on children's physical activity are imperative in the development of successful interventions (Brodersen et al., 2005; Uijtdewilligen et al., 2011; Van der Horst et al., 2007). Self-efficacy, perceived competence, enjoyment, attitudes and beliefs, environment, and social support have been consistently associated with children's physical activity (Biddle et al., 2011). Further, higher levels of physical activity are associated with being male (Riddoch et al., 2007; Wenthe et al., 2009), and being younger (Biddle et al., 2005). Beyond age and gender, though, most correlates are likely to have only small or small-to-moderate effects in isolation and may work best in interaction with other influences (Biddle et al., 2011).

A comprehensive review recommended that efforts to promote children's physical activity must take into account the developmental, psychological, and behavioural characteristics of children, and recognise the multidimensional correlates of children's physical activity (Van der Horst et al., 2007). Such correlates are organised in a hierarchical framework within the Youth Physical Activity Promotion Model (YPAPM; Figure 1.2; Welk, 1999), which is based on the fundamental principles of the Precede-Proceed health promotion model (Green et al., 1980). The YPAPM conceptualises a broad perspective on the factors that influence school-age children's habitual physical activity (Welk, 1999), incorporating physical activity correlates into a hierarchical structure. The model refers to four categories of correlates termed predisposing (i.e., attitudes, perceived confidence), enabling (i.e., motor skills, environment), reinforcing (i.e., parents, teachers), and personal demographic factors (i.e., age, gender). Demographic factors are positioned at the base of the model because these correlates directly influence how individuals assimilate other variables encapsulated in the enabling, predisposing, and reinforcing factors (Welk, 1999). Given that effective physical activity promotion interventions are based on known physical activity correlates (Sallis et al., 2000; Van der Horst et al., 2007), the YPAPM provides a framework for the development of the Children's Health, Activity, and Nutrition: Get Educated! (CHANGE!) intervention.

Figure 1.2. Conceptual diagram of the Youth Physical Activity Promotion Model (Welk, 1999)

Predisposing factors include variables that collectively increase the likelihood that a child will be physically active and involve psychological correlates. Physical activity behaviour is reduced to two questions: "Is it worth it?" and, "Am I able?". The first component addresses the cost/benefit assessment of participating in physical activity and incorporates attitudes, beliefs and enjoyment. The second question encompasses perceptions of competence and self-efficacy (Welk, 1999). It is a pervasive finding that self-efficacy, which is the belief in one's capabilities to successfully perform a task or activity (Bandura, 1997; Chase, 1998), is an important correlate of physical activity behaviour (Barr-Anderson et al., 2007; Biddle et al., 2005; Van der Horst et al., 2007). Further, perceived competence, which refers to a more global belief in one's ability in a specific domain (Chase, 1998), is positively associated with physical activity (Biddle et al., 2011).

Enabling factors consist of environmental and biological correlates, such as fitness, access and skills, and are those that allow and facilitate children to be physically active (Welk, 1999). Reinforcing factors are those social correlates (e.g., parental influences) which help to shape a child's predisposition towards physical activity (Welk, 1999). Parents directly influence children's physical activity behaviours and also dictate various physical and social environments that are available to their children (Ihmels et al., 2009). Despite good intentions, some families may unknowingly create an obesogenic environment that could predispose their children to becoming overweight (Ihmels et al., 2009). It has been consistently reported that instrumental parental support (i.e., transportation, encouragement, observation), family cohesion, and parent-child communication are significantly and positively related to child physical activity (Biddle et al., 2011; Ornelas et al., 2007). This emphasises the importance of the role of parents and the environment that they create for their children for the development of healthy sustained physical activity.

Personal demographics are important given that the proposed study will be a population-based approach, thus incorporating children from different socio-economic backgrounds. Socio-economic status (SES) is often thought to be an important correlate of physical activity. However, Biddle et al. (2011) stated that there is a surprisingly unclear link between low SES and children's physical activity, confirming a recent systematic review on socio-economic status and physical activity in adolescents (Stalsberg and Pedersen, 2010). Nonetheless, children from low SES families are more likely to engage in sedentary behaviours than high SES peers (Fairclough et al., 2009; Lioret et al., 2007), and overweight and obesity prevalence is highest in low SES children (Salmon et al., 2005). Therefore, these observations reinforce the need to design programmes which are culturally relevant and appropriate for the diversity of school children, considering personal demographic factors such as ethnicity, gender, age and SES (Goran et al., 1999), with low SES being of priority.

1.3: Organisation of Thesis

The central theme of the thesis is on physical activity levels of primary school aged children. A review of the literature is provided in **Chapter 2**. The key topics addressed are physical activity and health, children's physical activity levels, and the effects of school-based curriculum interventions on children's physical activity levels. The review attempts to critique the current literature, and highlight gaps which provide a rationale for the current research. **Chapter 3** presents a formative study: Using formative research to develop CHANGE!: A curriculum-based physical activity promoting intervention. Contemporary research suggests that population-specific cut-points are necessary to analyse intervention studies and this issue is addressed in **Chapter 4**. Study 3, reported in **Chapter 5**, evaluates the impact of the CHANGE! intervention on children's physical activity levels. The thesis concludes with a critical synthesis of the results from the three studies in **Chapter 6.** Conclusions from the research are drawn together in **Chapter 7**, and **Chapter 8** suggests future recommendations for both research and practice.

Chapter 2

Literature Review

2.1: Physical Activity and Health

The importance of promoting and engaging in regular physical activity is widely accepted as an effective preventative measure for a variety of health risk factors (Department of Health, 2011; Janssen and Leblanc, 2010; Tremblay et al., 2011). Physical activity has been identified as an integral contributor to a healthy lifestyle (Nelson et al., 2007) and can provide immediate and future health benefits (Strong et al., 2005). Studies with adult populations have concluded that strong relationships exist between physical activity and health, with higher physical activity levels leading to reduced risks of coronary heart disease (Li and Siegrist, 2012), hypertension (Peters et al., 2006), non-insulin-dependent diabetes mellitus (LaMonte et al., 2005), stroke (Goldstein, 2010), colon cancer (Wolin et al., 2009), osteoporotic fractures (de Kam et al., 2009) and depression (Martinsen, 2008).

The relationship between physical activity and health in children, however, is not so well established. A number of reviews of childhood physical activity and health have been conducted (Biddle and Asare, 2011; Biddle et al., 2004; Hallal et al., 2006; Janssen and Leblanc, 2010; Mountjoy et al., 2011; Strong et al., 2005), concluding that there is evidence of the beneficial effects of physical activity on musculoskeletal health, cardiorespiratory fitness, several components of cardiovascular disease (CVD), adiposity in overweight children, and blood pressure in mildly hypertensive adolescents. Bunker (1998) also suggested that physical activity can improve children's psychological well-being and promote moral reasoning, positive self-concepts, and social interaction skills. Thus, physical activity and fitness in childhood is associated with numerous health benefits (Kristensen et al., 2010; Ortega et al., 2011; Ortega et al., 2008; Ruiz et al., 2009), despite being deficient in many settings (Knuth and Hallal, 2009), and should therefore be promoted in children (Mountjoy et al., 2011).

Promoting physical activity in childhood is said to elicit three main benefits: (i) a direct improvement in quality of life and health status, (ii) a direct improvement in adult life status by delaying the onset of chronic diseases and, (iii) an indirect health gain through the increased likelihood of maintaining positive activity behaviours into adulthood (e.g., forming positive behaviours in childhood), again resulting in an improvement in adult heath status (Boreham and Riddoch, 2001). However, knowledge of total physical activity levels of children has been limited, primarily because activity has historically been assessed by self-report, but the criterion validity of self-reported instruments is low to moderate ($r = 0.3 - 0.4$) (Adamo et al., 2009; Chinapaw et al., 2010; Corder et al., 2008). The emergence of more precise, objective methods of assessing physical activity has greatly enhanced our understanding in this field. Recently, there is emerging evidence on the detrimental health effects of insufficient physical activity (Dencker and Andersen, 2008a; Janssen and Leblanc, 2010; Jimenez-Pavon et al., 2010; Mountjoy et al., 2011; Reichert et al., 2009) and high sedentary engagement (Tremblay et al., 2010) in children.

The risks to future adult health of decreased physical activity levels and increased childhood adiposity centre on metabolic complications such as type 2 diabetes and heart disease (Jolliffe and Janssen, 2007; Pan and Pratt, 2008). The onset of diseases such as coronary heart disease, stroke and osteoporosis are more likely to occur in adulthood, therefore the frequency of incidents cannot be easily related to childhood physical activity levels (Boreham and Riddoch, 2001). Such measurement issues have been addressed by research in paediatric populations focusing on disease risk factors such as bone mineral density (BMD), blood pressure, fatness, and blood lipids, as indicators of future health problems (Andersen et al., 2006; Klasson-Heggebo et al., 2006). It is widely accepted that CVD and metabolic syndrome have their origins in childhood, although clinical symptoms may not become apparent until later in life (Gutin and Owens, 2011). There has been recent, consistent, evidence that a high proportion of children exhibit one or more risk markers, such as hypertension, endothelial dysfunction, high cholesterol levels, and inflammatory mediators (Thomas and Williams, 2008). It should be noted however, that the measurement of risk factors is further complicated by the stage of the child's development (Raitakari et al., 1994). Further, methodological weaknesses in assessing physical activity, lack of sensitivity in health risk markers, as well as few well conducted, large scale, longitudinal studies, limit causal relationships between physical activity and health in children (Corder et al., 2008; Mountjoy et al., 2011; Reilly et al., 2008).

Despite aforementioned difficulties, cross-sectional research has found that children's habitual physical activity is inversely related to metabolic syndrome, clustering of CVD risk factors, waist circumference, diastolic blood pressure, insulin resistance, and triglycerides (Andersen et al., 2006; Janssen and Leblanc, 2010; Pan and Pratt, 2008; Rizzo et al., 2007). Specifically, curvilinear relationships have been found between cardiorespiratory fitness and anthropometrical measures (waist circumference and sum of four skin folds) in 9 year old children (Klasson-Heggebo et al., 2006). In contrast, earlier research (Boreham et al., 2002) reported that no such relationships were apparent between adolescents' physical activity and selected coronary risk factors (blood pressure, sum of skin fold thickness and serum cholesterol). It must be acknowledged that the wide variety of methods employed to assess physical activity may have confounded the evidence, and there is no clear consensus on the most appropriate cut-points to use when measuring physical activity by accelerometry (Corder et al., 2008). However, positive relationships have been reported in primary school children between physical activity and fitness (Brage et al., 2004), and physical activity and BMD (Tobias et al., 2007). Specifically, recent research found beneficial effects of physical activity on BMD during growth (Macdonald et al., 2009; Nikander et al., 2010; Rizzoli et al., 2010), and a consistent long-term protective effect of adolescent physical activity on bone health has been established (Kohrt et al., 2004).

Participation in regular physical activity in childhood can enhance growth and development and have beneficial effects on psychological well-being (Biddle and Asare, 2011; Biddle and Mutrie, 2008). For example, physical activity has been shown to improve physical self-perceptions and self-esteem in children (Fox, 2001), although effects are inconsistent (Keeley and Fox, 2009). A recent review found that physical activity is likely to have positive psychosocial outcomes for children, such as enhanced self-esteem and reduced anxiety

(Biddle and Asare, 2011). However, there is a paucity of a good quality research base; the majority of studies are cross-sectional, thus causality cannot be inferred.

Appropriate levels of physical activity can confer fitness while lowering the risk of obesity and health risks associated with increased fatness (Fogelholm, 2010; Hamer and O'Donovan, 2010; Ness et al., 2007). Of concern, children's levels of fitness, a product of physical activity and an independent risk factor for chronic disease (Andersen et al., 2006), have declined independent of changes in body size (Stratton et al., 2007; Tomkinson et al., 2003). Although the causes of obesity are multi-factorial, physical activity and sedentary behaviour are key implicated variables, due to their influence on energy balance. Furthermore, the prevalence of overweight and obesity is a public health burden at all ages because of links to obesity and other hypokinetic conditions (Allender et al., 2007). Moreover, paediatric obesity in particular has been associated with increased risk of cardiometabolic illness in later life (Freedman et al., 2007). Research has shown that the prevalence of obesity has plateaued across the world (Lissner et al., 2010; Rokholm et al., 2010), and specifically the United Kingdom (UK; Boddy et al., 2010). Nonetheless, the prevalence of obesity still remains extremely high and previous stable phases have been followed by further increases (Cali and Caprio, 2008).

Previous cross-sectional studies reported that lower levels of physical activity are related to a higher risk of obesity in children, adolescents and adults (Besson et al., 2009; Jimenez-Pavon et al., 2010). However, the cross-sectional design of these studies hampers the interpretation of the results as there is lack of evidence that physical inactivity precedes obesity in children (Steinbeck, 2001); it is not clear whether low levels of physical activity cause excess weight gain, or whether overweight people are less likely to engage in physical activity. There are, however, good reasons for believing that physical inactivity is causally related to obesity in children. Changes to the gene pool are unlikely to explain the increased global prevalence of obesity, and, in the absence of such changes, diet and physical activity appear the most likely candidates (Goran and Treuth, 2001). Moreover, Li et al. (2010b) suggested that higher physical activity levels attenuate the genetic predisposition to obesity. Despite data on the relationship between physical activity and obesity in children being inconsistent (Venn et al., 2007), most research suggests that overweight and obese children are less active than their healthy weight counterparts (Hills et al., 2007; Planinsec and Matejek, 2004; Strong et al., 2005). A recent review concluded that there appears to be a strong relationship between physical activity and obesity in children (Hills et al., 2011) and higher levels of physical activity translate into greater benefits (Colley et al., 2011). Physical activity also contributes improvements in body composition and assists in maintenance of weight loss (Jakicic, 2009).

There is growing literature on children and adults sedentary behaviour as a result of the amount of time people spend sitting, partly contributed to by the rapid developments in technology making home-based entertainment systems highly attractive and accessible. Moreover, the pervasive nature of car travel in place of active forms of transport from previous generations has added to concerns about excessive sedentary behaviour and health (Marshall et al., 2006; Owen et al., 2010; Tremblay et al., 2010). Deleterious health outcomes of high levels of sedentary behaviour are emerging in adults (Grontved and Hu, 2011; Hamilton et al., 2008; Owen et al., 2010) but have proved more difficult to demonstrate in children. Nonetheless, studies in children have shown that sedentary behaviour can be associated with higher risk of overweight (Hancox et al., 2004; Marshall et al., 2004), hypertension (Pardee et al., 2007), adverse metabolic markers (Ekelund et al., 2006), and poorer mental health (Primack et al., 2009). Moreover, research has shown that obese children are more sedentary than their non-obese counterparts (Epstein et al., 2001).

It is generally accepted that the onset of many diseases and conditions lie in early life (Klasson-Heggebo et al., 2006), as a result preventive strategies, including beneficial physical activity patterns, should start at an early age. Interventions to increase children's physical activity levels are therefore crucial to help form life-long healthy behaviours.

2.2: Tracking of Physical Activity, Sedentary Behaviour and Obesity

Blair et al. (1989) hypothesised a number of relationships that linked childhood activity to adult health, and adult activity. Specifically, (i) childhood physical activity influences adult physical activity, which may affect adult health, (ii) childhood physical activity has a direct beneficial effect on child health, which predicts adult health and, (iii) childhood physical activity has a direct beneficial effect on adult health. Consequently it is important to track physical activity and health behaviours. Tracking has been defined as the stability of health behaviours over time (Malina, 1996). Related to physical activity, tracking implies that engagement in physical activity during childhood will carry over into adolescence, and adulthood.

Short-term studies (2 – 5 years) indicate that physical activity tracks moderately well from early to middle childhood (r = 0.57 – 0.66; Pate et al., 1996) and childhood to adolescence (r = 0.32 – 0.65; Janz et al., 2000; Kelder et al., 1994). However, the relationship between physical activity and health in children is still not well established and can be partly attributed to a lack of longitudinal studies that have tracked children from childhood through into adulthood. Nonetheless, large-scale studies such as the Amsterdam Growth and Health Longitudinal Study and the Northern Ireland Young Hearts Study have tracked physical activity, body composition, and fitness from childhood into adulthood (Boreham et al., 2004; van Mechelen and Kemper, 1995). Data from the Amsterdam Growth and Health Study over a 14 year period (ages 13 to 27 years) concluded that the long-term stability of physical activity can be considered as low to moderate (Twisk et al., 2000). Further, a 21 year tracking study reported that high levels of physical activity in childhood significantly predicted high levels of physical activity in adulthood, despite low to moderate correlations being found (Telama et al., 2005). Conversely, longitudinal studies tracking physical activity from childhood and adolescence to adulthood (7 - 36 years) have reported weak associations (Beunen et al., 2004; Boreham et al., 2004; Trudeau et al., 2004), and therefore inferred that childhood physical activity levels cannot predict adult physical activity (Beunen et al., 2004). More recent longitudinal research over 18 to 20 years found that childhood and adult physical activity were weakly correlated (r = 0.07 – 0.14) (Cleland et al., 2011; Cleland et al., 2009; Friedman et al., 2008).

Overall, reviews of tracking of physical activity from childhood to adulthood conclude a low to moderate relationship (Craigie et al., 2011; Hallal et al., 2006). However, Boreham and Riddoch (2001) propose that substantial tracking should not be expected in the case of physical activity as many factors can influence this behaviour (i.e., major life events including school to work transition, leaving home, marriage, illness, etc.). In addition, physical activity is a complex multidimensional behaviour where accurate assessment is difficult (Craigie et al., 2011). Despite the apparent lack of tracking evidence, it is likely that physical activity will provide some benefit to children and adolescents' current and future health (Singh et al., 2008; Strong et al., 2005).

Experimental data suggest that children face an increasing array of sedentary behaviours, which may be more reinforcing than physical activity (Vara and Epstein, 1993), even when physically active alternatives are available (Epstein et al., 1991). Reallocating small amounts of sedentary time in favour of more active behaviours has been shown to significantly impact on positive health outcomes (Epstein and Roemmich, 2001). Physical (in)activity and sedentary behaviours track from childhood into adulthood (Biddle et al., 2010; Janz et al., 2000). Research and reviews of European and North American studies conclude that sedentary behaviour tracks more strongly than physical activity (Janz et al., 2005). Specifically, children's television viewing was more predictable and stable ($r = 0.37 - 0.52$) than overall activity ($r = 0.18 - 0.39$), over a 3 year period (Janz et al., 2005). Further, television viewing is associated with obesity for both boys and girls (Shields and Tremblay, 2008).

A number of potential health consequences are associated with excess body fat during the growing years and, without effective intervention, the risk of ill health escalates throughout the adult years (Hills et al., 2011). It has been suggested that childhood obesity is a strong predictor of obesity in adulthood (Whitaker et al., 1997), as well as excessive weight gain (O'Loughlin et al., 2000) and is associated with health problems in adulthood independent of adult weight status (Must, 2003). Childhood obesity tracks through adolescence (Freedman et al., 2006) and into adulthood (Singh et al., 2008; Yang et al., 2007), with estimates that at least 60% of obese children maintain this condition into their adult years (Reilly and Wilson, 2007). Boreham et al. (2004) demonstrated poor to fair tracking of anthropometric variables such as weight, BMI and sum of skinfolds. Conversely, longitudinal studies have consistently reported a moderate to high degree of BMI tracking ($r = 0.54$) from childhood and adolescence to adulthood (Guo et al., 2002; Kvaavik et al., 2003; Whitlock et al., 2005). Such research suggests that the foundation for adult body weight is accumulated during childhood. In addition, further longitudinal studies have concluded that obesity tracked significantly from childhood to adulthood ($r = 0.36 – 0.42$), and that high BMI values at young ages were independent predictors of being overweight in adulthood regardless of gender (Yang et al., 2007).

Although CVD events occur most frequently later in life, there is evidence indicating that the precursors of CVD have their origin in childhood and adolescence (Andersen et al., 2006; McGill et al., 2000). Research has shown that CVD risk factors during childhood seem to track into adulthood (Raitakari et al., 2003). Physical fitness is related to a healthy CVD risk profile (Twisk et al., 2002), though fitness has only shown poor to fair tracking in both boys and girls

(Boreham et al., 2004). However, recent research has suggested that there may not be a direct relationship between childhood obesity and cardiovascular risk factors in adulthood, but instead an indirect relationship through the tracking of obesity from childhood to adulthood (Lloyd et al., 2010).

Physical activity may be particularly important in addressing the increasing prevalence of childhood overweight and obesity, which in developed countries is a major public health concern. The results provide some indication as to the benefit of a physically active childhood on both child and adolescent health, providing greater impetus to the development of interventions (Brown and Summerbell, 2009; Summerbell et al., 2005). As the measurement of physical activity and health advances, these relationships may become clearer in future empirical studies.

2.3: Physical Activity Guidelines

There is a general consensus that the promotion of physical activity is a public health priority. In light of this, physical activity recommendations have been developed for children, providing thresholds to enable researchers to determine whether children are sufficiently active to accrue health benefits. Furthermore, they can establish priority target groups for health promotion messages.

Despite the lack of unequivocal evidence of the link to health outcomes, it is critical that all children and adolescents accumulate sufficient physical activity. The most recent physical activity guidelines propose that children and young people should undertake a range of moderate-to-vigorous activities, for at least 60 minutes each day (Department of Health, 2011). Moderate-to-vigorous physical activity (MVPA) refers to activities which results in increasing heart rate, sweating and breathing harder or being out of breath (NICE, 2009), such as brisk walking, skipping or bike riding. Further, vigorous intensity activities, including those than strengthen muscle and bone, should be incorporated at least three days a week. Martinez-Gomez et al. (2010) stated that recent guidelines appear appropriate to prevent the accumulation of body fat in European adolescents. Research indicates that whilst sustained bouts of activity are important for cardiorespiratory fitness (Payne and Morrow, 1993), health benefits can be gained through the accumulation of at least moderate intensity physical activity across the day (Boreham and Riddoch, 2001).

The current recommendations of 60 minutes MVPA were initially proposed in a consensus statement in 1998 (Biddle et al.). However, concern has been expressed that the recommendations have only a limited scientific basis (O'Donovan et al., 2010), and the level of physical activity may not be enough to prevent weight gain (Andersen et al., 2006; Boreham and Riddoch, 2001) and the appearance of CVD risk factors (Andersen et al., 2006) in children. Investigating the association between physical activity and the clustering of cardiovascular risk factors in 9 year old children, Andersen et al. (2006) found that there was a graded negative association, with risk being raised in the first to third quintile of physical activity. Andersen and colleagues (2006) reported that the time spent engaged in MVPA was 116 minutes in the fourth quintile, raising concerns that the recommendation of one hour of physical activity per day in at least moderate activity intensity (Department of Health, 2011) may underestimate the daily activity required to prevent clustering risk factors in children. Despite the study being cross-sectional in design, and monitoring children's physical activity levels using a one minute epoch, which could arguably underestimate physical activity levels (Cliff et al., 2009), this study highlights that primary school children may need to engage in double the current recommended activity guideline to benefit health.

In light of the growing evidence suggesting that sedentary behaviour has an independent and significant impact on health (Tremblay et al., 2011), the Department of Health (2011) guidelines state that all children should minimise the amount of time spent being sedentary for extended periods. However, recently the Canadian Society for Exercise Physiology (CSEP) published the first evidence-based guidelines on sedentary behaviour for children and adolescents (Tremblay et al., 2011). The CSEP guidelines recommend that children limit sedentary transport (i.e., motorised transport) and reduce daily screen time (television, computer, etc.) to less than two hours (Tremblay et al., 2011).

2.4: Physical Activity Levels

Considerable interest has been directed towards determining physical activity levels amongst paediatric populations. There is on-going debate as to whether children are sufficiently active to accrue current and future health benefits. Of concern, research suggests that many children are not meeting the recommended physical activity guidelines (Hills et al., 2011) and engage in up to several hours of sedentary behaviour daily (Steele et al., 2010). However, the prevalence of children's physical activity varies depending upon assessment method employed (Corder et al., 2008).

Numerous physical activity measures have been used in paediatric research, such as self-report, direct observation and objectively measured techniques, such as accelerometry (Corder et al., 2008). The percentage of children meeting these guidelines tends to be overestimated when using self-report methods (Adamo et al., 2009), which may be influenced by the ability of the children to recall retrospectively, and the potential for children to respond in a socially desirable manner (Biddle et al., 2009; Corder et al., 2008; Gorely et al., 2009a). Recent self-report data for England (Health Survey for England, 2009) suggests that only 32% of boys and 24% of girls aged 2-15 years achieved the recommended levels of physical activity. In a nationally representative sample in the US, data from the Youth Risk Behavior Survey reported 24.8% of boys and 11.4% of girls were physically active for at least 60 minutes on all 7 days (Centers for Disease Control, 2010). Of interest, Li et al. (2010a) recently reported that self-reported physical activity levels have not declined during recent decades. This consensus was supported by objectively assessed data (Moller et al., 2009; Raustorp and Ekroth, 2010). This said, Ekelund and colleagues (2011) advised that data on temporal trends should be interpreted cautiously as physical activity levels may have declined in domains (i.e., household chores, leisure time physical activity) not assessed by such methods.

Gorely et al. (2009a) reported that 63% and 50% of boys in the UK reached recommended physical activity levels on week and weekend days, respectively, when utilising ecological momentary assessment (EMA) diaries, which allow children to report not only their physical activity behaviours, but also environmental and social factors (Biddle et al., 2009). Conversely, Biddle et al. (2009) reported that Scottish boys engaged in 62 minutes physical activity on weekdays and 91 minutes on weekend days. Girls engaged in less physical activity, accumulating 55 minutes and 47 minutes, for week and weekend days, respectively (Biddle et al., 2009). However, EMA does not incorporate an intensity component, therefore it is unknown how long was spent in light, moderate, or vigorous intensity. Moreover, as both these studies focussed on volitional leisure time behaviour, the figures for weekday physical activity are likely to be underestimated, given that school time physical activity behaviours were not assessed (Biddle et al., 2009; Gorely et al., 2009a). However, the trend of the data is in agreement with Nader et al. (2008) who found that weekend MVPA was less than weekday MVPA and that boys were more active than girls, when using accelerometry.

Accelerometry is the most commonly used objective measure to assess the volume and intensity of physical activity (Corder et al., 2008). Accelerometers have been previously validated with children (Ekelund et al., 2001; Trost et al., 1998), are able to store large amounts of data, and are relatively unobtrusive and practical (Freedson et al., 2005). Moreover, the ActiGraph has shown good potential for documenting the natural physical activity patterns of children (Dale et al., 2000). Nevertheless, accelerometers are limited by their capacity to assess static physical activities, and cannot accurately capture certain terrain changes (i.e., gradient) or non-weight-bearing activities that require little body movement (Corbin et al., 2004). Notwithstanding the limitations of accelerometers, these instruments may arguably be the best method of assessing children's free living physical activity (Cooper et al., 2005). Large variation however exists in the cut-points used to define moderate physical activity (MPA), vigorous physical activity (VPA) and sedentary time, which consequently impacts on accurate estimation of physical activity levels (Youngwon et al., in press). Specifically, Guinhouya et al. (2009b) observed statistically significant differences in MVPA when MPA cut-points differed by as little as 90 counts•min^{-1}. There is therefore on-going debate concerning how arbitrary accelerometer counts translate into more meaningful and interpretable units (Freedson et al., 2005). The generation of accelerometer cut-points have typically arisen from laboratory-based protocols (Alhassan and Robinson, 2010; Evenson et al., 2008), though some field-based protocols have been used (Sirard et al., 2005; Van Cauwenberghe et al., 2010). Such protocols allow parallel measurement of energy expenditure (EE) by indirect calorimetry whilst controlling for physical activity intensity. However, inconsistencies between studies have resulted in a range of thresholds and has consequently produced discrepancies in the number of children and adolescents classified as being sufficiently active (Mota et al., 2007). Recent research has addressed such an issue by developing prediction equations to allow direct comparison between studies employing different cut-points for pre-school aged children (Bornstein et al., 2011). This is a contentious issue and the number of thresholds available highlights the lack of agreement among leading researchers, as no consensus exists on how to satisfactorily tackle this problem (Rowlands and Eston, 2007).

Despite acknowledged challenges in the objective assessment of physical activity in children, there is evidence that many children participate in considerably less physical activity than is recommended for health (Reilly et al., 2004; Riddoch et al., 2007). Approximately 30% of boys and 40% of girls in the UK fail to meet current physical activity guidelines (The Information Centre, 2006). This said, Riddoch et al. (2007) suggested that as little as 2.5% of children (5.1% of boys, 0.4% of girls; mean age 11.8 years) meet current internationally recognised recommendations, when high cut-points are used. Further, data from the European Youth Heart Study (EYHS; Riddoch et al., 2004) reported that 97% of 9 year old children achieved current physical activity recommendations, in comparison to 62% and 82% of 15 year old girls and boys respectively. Van Sluijs et al. (2008) reported British 9-10 year old children to engage in, on average, 74.1 minutes of MVPA per day, with 69.1% of children meeting current physical activity guidelines. These contrasting results may be explained by the use of different cut-points of accelerometer counts to define the MVPA threshold (Riddoch et al., 2007). Of particular concern is the decline in physical activity levels in the period of transition from childhood to adolescence. Nader et al. (2008) found that children's physical activity levels decline as they progress into adolescents. Nine year old children engaged in 3 hours of MVPA on both week and weekend days, whereas 15 year olds only accrued 49 minutes and 35 minutes, respectively (Nader et al., 2008). This reduction in physical activity with increasing age has also been reported in Canada (Sherar et al., 2007). These results strongly support the concept that physical activity declines rapidly during childhood and adolescence.

Moving away from arbitrary population-wide cut-points, Ekelund et al. (2003) applied individually calibrated activity thesholds to habitual physical activity. ArteACC (the activity-related time equivalents based on accelerometry index) is calculated as: ArteACC (minutes per day) = total daily activity counts (ACs) (counts•day^{-1})/reference exercise ACs (counts•min^{-1}) (Ekelund et al., 2003). However, this approach is time consuming and consequently difficult to apply to large samples (Jago et al., 2007). Stone et al. (2009) concluded that activity thresholds (i.e., sample-specific thresholds, published thresholds (Mattocks et al., 2007), and the ArteACC (Ekelund et al., 2003)) did not impact on relationships detected between time boys spent in MVPA and health outcomes, however, intensity thresholds clearly matter when reporting the percentage of children meeting MVPA guidelines.

A study found that Scottish adolescents spent 228-244 minutes and 396-400 minutes for week and weekend days respectively, engaged in their top five most sedentary activities (Biddle et al., 2009). Moreover, adolescents television watching occupied the most leisure time. Prevalence estimates of sedentary behaviour, including television viewing (Biddle et al., 2009), is lacking in UK children. However, in North America it is estimated that approximately 29% of boys and 23% of girls aged between 9 and 16 years watch in excess of 4 hours television per day, with similar estimates reported in European countries (Biddle et al., 2004).

Research in this area has suggested reasons for the varied conclusions surrounding physical activity levels including measurement error, different measurement methods, population and age group differences, the measurement of different dimensions of physical activity, seasonal effects, and potential decreases in physical activity levels over time (van Sluijs et al., 2008). Riddoch and Boreham (1995) conclude that the physcial activity evidence of children is equivocal and methodogolically diverse, as measurement is problematic. Despite this, Biddle et al. (2004) suggest that it remains a concern that a sizeable portion of children continue to have what might be described as inactive lifestyles.

2.5: Parental Influences on Children's Physical Activity

The family has been considered an important agent of socialisation, given that children spend the majority of their time within the context of the family during the formative years (Tinsley, 2003). Parents teach skills and inculcate beliefs, which can ultimately shape important attitudes and behaviours associated with children's physical activity behaviours, through both direct and indirect forms of socialisation (Bois et al., 2009). The indirect effects may be mediated, in part, through established social-cognitive-based constructs, such as encouragement, support, and to a lesser extent, role modelling (Welk et al., 2003). More directly, parents operate a gatekeeper role in determining what activities children do, what resources and access they have available, and whether they are actively involved in active games with their child (Welk et al., 2003). As such, parental involvement in physical activity interventions is warranted.

A recent systematic review found that parents provide a target for interventions to increase children's physical activity through encouragement to promote the importance of physical activity, either through their own behaviour or supporting their child to be active (Edwardson and Gorely, 2010b). Specifically, cross-sectional data for children showed a positive association between mother modelling and MVPA, parental involvement and overall physical activity, father modelling and parental involvement with leisure-time physical activity, and finally overall support and organised physical activity. Such findings therefore suggest that to facilitate activity for children aged 6 - 11 years old, parents may need to be directly involved in participating in physical activity themselves (Edwardson and Gorely, 2010b). Moreover, children who perceive their mother and/or father to be physically active are more likely to engage in physical activity.

However, for children to engage in organised physical activity parents may need to provide broader support and facilitate their child's physical activity by encouraging their child to be active, transporting their child to places where they can be active, as well as being active role models for their child. However, despite such evidence conveying benefits of including parents in children's physical activity interventions (Dowda et al., 2007), there is not only a lack of home-based interventions, but a lack of success for such interventions (van Sluijs et al., 2007). This said, school-based interventions can incorporate some parental involvement, mainly through newsletters and homework assignments. Although the evidence of combined school and parental interventions is strong in adolescents, the evidence in children is still inconclusive, and whether the strategy of involving parents in interventions will be as effective for children has been advocated as a key focus for future research (van Sluijs et al., 2007).

2.6: School as a Health Promotion Context

Schools have been identified as a key setting for health promotion and an influential mechanism to engage children in physical activity (Harrell et al., 1999; Warren et al., 2003). For this reason, schools are suitable for physical activity interventions (van Sluijs et al., 2007), capturing approximately 40% of a child's walking time (Fox et al., 2004) and, arguably, an even greater proportion of their opportunities to be physically active. Moreover, schools can reach a large number of children from diverse socio-economic backgrounds (Fox et al., 2004). Further, almost all children spend most of their days in school and family-based interventions have been shown to be of limited effectiveness (Salmon et al., 2007; van Sluijs et al., 2007). Schools represent an important part of children's lives and provide an opportunity to improve the quality and quantity of health and well-being information given to children and their families (NICE, 2009; Naylor and McKay, 2009). Schools also have personnel who, with sufficient training and enthusiasm, can design and deliver effective physical activity interventions, establish and enforce healthy lifestyle policies, and serve as powerful role models for students (Wechsler et al., 2000). Furthermore, sustainable interventions that can be implemented by school personnel in 'real life' conditions (i.e., without researcher support and resources) are advocated (De Bourdeaudhuij et al., 2011), as these are less costly (Warren et al., 2003) and are more likely to be integrated within existing curricula and maintained over time. Better targeted, more effective physical activity promotion in schools aims to instil positive health behaviours early on and maintain them into adolescence (Fox, 2004).

Although Physical Education (PE) is the traditional setting for physical activity promotion within schools, PE alone may not provide adequate physical activity in order to gain associated health benefits (Biddle et al., 2004). For this reason, Personal and Social Health Education (PSHE) has been identified as a complementary opportunity where children can learn about healthy lifestyles and behaviour change. Moreover, interventions targeting curriculum areas such as PSHE can be easily integrated into the daily routine of schools, as well as targeting physical activity promotion at home (Siegrist et al., 2011).

2.7: School-based Physical Activity Intervention Studies

Researchers have advocated that well-designed and well-implemented school-based programmes can improve the physical activity and health of children (Naylor et al., 2006; Reed et al., 2008; Verstraete et al., 2007). School-based physical activity interventions have successfully increased children's MVPA (Fitzgibbon et al., 2011; Gorely et al., 2009b; Magnusson et al., 2011). Brown and Summerbell (2009) stated that although school-based interventions have potential to help children maintain a healthy weight through increasing physical activity and decreasing sedentary behaviour, evidence is inconsistent and short-term. For example, a recent meta-analysis (Harris et al., 2009) found that although school-based physical activity interventions did not improve BMI they had other beneficial health effects. Conversely, Lavelle et al. (2012) found growing evidence that school-based interventions containing a physical activity component may be effective in helping to reduce BMI in children.

A recent review conducted by Kriemler et al. (2011) concluded that there is strong evidence for the positive effect of school-based interventions on physical activity in children. Physical activity promotion in the school setting leads to an increase in school-based physical activity and is associated with an increase in out of school physical activity, and even more importantly, overall physical activity (Kriemler et al., 2011). Five studies employing objective physical activity assessment were effective at increasing total physical activity (Gentile et al., 2009; Gorely et al., 2009b; Kriemler et al., 2011; Naylor et al., 2008; Salmon et al., 2008), though some only found significant differences in a sub-group (Gentile et al., 2009; Naylor et al., 2008). Specifically, physical activity during school time was increased (Verstraete et al., 2007).

Perhaps the most extensive examination of potential mediators in physical activity interventions in children incorporating a family component, and therefore a key school-based intervention worthy of discussion, was performed in the Child and Adolescent Trial for Cardiovascular Health (CATCH), a multi-component randomised controlled trial based in 96 elementary schools (Luepker et al., 1996; Nader et al., 1999). Examining the effects of a school-based intervention to increase physical activity, initially in third grade children, CATCH significantly increased physical activity in the Intervention group when measured in fifth grade (Luepker et al., 1996), in addition to increases in self-efficacy and perceived social support during the active intervention (Nader et al., 1999). Participants self-reported vigorous physical activity remained higher in the Intervention group at an eighth grade follow-up (Nader et al., 1999). Family-based interventions have attempted to change health behaviours, with the family component being conceptualised as an adjunct home curriculum to school activities, involving take-home packs, reward systems, and family record keeping (Kahn et al., 2002). Family-oriented events, such as the 'Family Fun Nights' incorporated in the CATCH programme, have been well-received by parents (Pate and O'Neill, 2009). More specifically, a cross-sectional intervention for 9 year old children and their parents indicated that availability of transportation by parents was significantly associated with total physical activity for both boys and girls, with parents who played with their children being correlated with more active boys (Sallis et al., 1993). Two interventions involving non-competitive physical activity were effective in increasing physical activity in after-school interventions, with high adherence rates (Gutin et al., 2008; Vizcaino et al., 2008). Despite not being based in the UK, the 'FitKid' intervention targeted older primary school children, integrating 80 minutes of physical activity (at least half of which was vigorous intensity), homework time, and a healthy snack into two hours of an after-school club (Gutin et al., 2008). Of interest, the academic enrichment portion was highly praised by parents and school personnel. Accordingly, available evidence indicates that after-school physical activity interventions can be both enjoyable and effective in increasing children's physical activity levels (Pate and O'Neill, 2009). Moreover, Pate and O'Neill (2009) described several advantages to after-school programmes which centred on, (i) their potential to significantly increase children's physical activity levels and therefore help accumulate the recommended 60 minutes MVPA per day, (ii) provision of a safe environment during after-school hours, (iii) the elimination of barriers to children whose parents perceive their neighbourhood as being unsafe, and (iv) allowing time for children to spend with friends and adults who are positive role models. In order to be successful though, after-school programmes may need to help children overcome barriers to attending. For example, Robinson et al. (2008) reported how barriers of low income and neighbourhood safety were overcome by providing transportation for physical activity participants from schools to intervention facilities. Finally, some school-based interventions that have combined environmental changes with education programmes have demonstrated potential in promoting sustainable behaviour change (Haerens et al., 2006; Sallis et al., 2003; Simon et al., 2004). Based on the published evidence to date, it seems intuitive that a multi-component approach to promoting physical activity, combining school-based interventions with family and community involvement is likely to be effective among children (van Sluijs et al., 2007).

An example of examining the effectiveness of a whole-school approach to promoting healthy eating and physical activity, specifically in UK primary schools (n = 10) was demonstrated in the APPLES trial (Sahota et al., 2001a; Sahota et al., 2001b). The programme included environmental changes (e.g., school lunches), teacher training, physical education and playground activities. No differences were observed in self-reported frequency of physical activity among children in the Intervention schools compared with the Control schools but there was a modest increase in vegetable consumption. Utilising lunchtime clubs a pilot randomised controlled trial examined the effectiveness of individual and combined physical activity and healthy eating curriculum interventions in 3 UK primary schools (Warren et al., 2003). Participants (5 – 7 year olds) were randomly allocated to one of 4 groups: nutrition group, physical activity group, combined group, or control group. The setting for the intervention was 25 minute long lunchtime clubs where an interactive and age-appropriate nutrition and/or physical activity curriculum was delivered over 20 weeks spread across 4 school terms. There was no clear effect of programme type on either fruit and vegetable consumption or self-reported or parent-reported physical activity, with improvements generally being seen across all groups.

Many intervention studies have attempted to increase levels of habitual physical activity with varied success (Summerbell et al., 2005). Such contradictions may be due to methodological problems such as not incorporating objective measurements of physical activity (Mountjoy et al., 2011), failing to account for relevant confounders and clustering in analyses, and not employing robust study designs (van Sluijs et al., 2007). Despite such weaknesses in the evidence base, systematic reviews suggest that curriculum-based approaches to health promotion and intervention have been observed to be effective (Gorely et al., 2009b; Naylor and McKay, 2009) when physical activity and healthy eating are targeted together using established behaviour change and social support processes (Greaves et al., 2011; Kriemler et al., 2011; van Sluijs et al., 2007). Furthermore, a recent systematic review reported that 45% of reviewed studies demonstrated significant intervention effects on BMI (Brown and Summerbell, 2009). In Europe there is limited evidence of successful school-based curriculum interventions focused on physical activity and/or healthy eating, with improvements in school time physical activity reported (Warren et al., 2003), but no effects on weight status (De Bourdeaudhuij et al., 2011). Conversely, it is postulated that lifestyle interventions to reduce the risk of overweight may be better implemented if built into school curricula, particularly through interdisciplinary curriculum areas such as PSHE (Warren et al., 2003).

The rationale for school-based interventions is based on the volume of time children spend there, but children typically engage in less physical activity when at home (Duncan et al., 2011). Children are less active at weekends compared to weekdays (Fairclough et al., 2012b) when they are at school. Evidence suggests that to enhance the effectiveness of school-based interventions beyond the school environment some form of parental and family involvement is required (Pearson et al., 2009; Salmon et al., 2007; van Sluijs et al., 2007). The parental component has involved newsletters or homework assignments to be completed with parents.

2.8: Summary

The promotion of physical activity has been identified as a public health priority. In particular, enabling children to engage in physical activity during childhood may prevent the clustering of CVD risk factors (Andersen et al., 2006), and since high levels of physical activity in childhood have been found to significantly predict high levels of physical activity in adulthood, despite low to moderate correlations being found (Telama et al., 2005), childhood physical activity may reduce the health risks associated with inactivity and benefit health in adult life (Andersen et al., 2006). The school has been acknowledged as a logical setting for the promotion of physical activity to children (van Sluijs et al., 2007), as the majority of children attend school and a large proportion of the child population can be reached (Fox et al., 2004). Indeed, the school has a health education infrastructure that exists through the formal curriculum that educates children about the need for physical activity as well as developing their knowledge of how to be physically active (Killen and Robinson, 1988). The promotion of physical activity to children via a curriculum-based health promotion intervention has shown promise (Gorely et al., 2009b; Gortmaker et al., 1999a). It is postulated that lifestyle interventions to reduce the risk of overweight may be better implemented if built into school curricula, particularly through interdisciplinary curriculum areas such as PSHE (Warren et al., 2003).

Further, recent research has indicated that school-based interventions are more successful when a family component is integrated (Pearson et al., 2009; van Sluijs et al., 2007), as children typically engage in less physical activity and consume unhealthy foods when at home (Duncan et al., 2011).

2.9: Aims of Thesis

This programme of research will develop, implement and assess the effect of the Children's Health, Activity and Nutrition: Get Educated! (CHANGE!) project. The CHANGE! project targets physical activity and healthy eating through a school-based curriculum intervention delivered by in-service teachers. This approach has previously been utilised in the USA and UK with some degree of success through programmes such as Planet Health (Gortmaker et al., 1999b; Kipping et al., 2010; Kipping et al., 2008).

Study 1 objectives.

- Elicit the views of primary school children aged 9-10 years old, their parents, and teachers in relation to their own knowledge, behaviours and perceptions towards childhood physical activity.
- To examine perceived benefits and barriers to physical activity participation.
- Use these data to subsequently inform the design of a tailored physical activity intervention programme, CHANGE! (Children's Health, Activity, and Nutrition: Get Educated!).

Study 2 objectives.

- To test a field-based protocol to generate behaviourally valid, population-specific accelerometer cut-points for sedentary behaviour, moderate, and vigorous physical activity.
- Use these cut-points to subsequently analyse physical activity data for CHANGE!.

Study 3 objective.

- To assess the effect of the CHANGE! school-based physical activity intervention on habitual physical activity and body size in 10-11 year old children.

Thesis Study Map

A thesis study map appears at the beginning of each study chapter to demonstrate the objectives and key findings of the studies, and demonstrate where each study fits in to the overall thesis.

Study	Objectives and Key Findings
Study 1: Using formative research to develop CHANGE!: A curriculum-based physical activity promoting intervention	**Objectives:** • **Elicit the views of primary school children aged 9-10 years old, their parents, and teachers in relation to their own knowledge, behaviours and perceptions towards childhood physical activity.** • **To examine perceived benefits and barriers to physical activity participation.** • **Use these data to subsequently inform the design of a tailored physical activity intervention programme, CHANGE! (Children's Health, Activity, and Nutrition: Get Educated!).**
Study 2: A calibration protocol for population-specific accelerometer cut-points in children	
Study 3: Promoting healthy body size in Primary school children through physical activity education: The CHANGE! intervention	

Chapter 5: Study 3

5.1: Introduction

The importance of promoting and engaging in regular physical activity is widely accepted as an effective preventative measure for a variety of health risk factors (Department of Health, 2011; Janssen and Leblanc, 2010; Tremblay et al., 2011). The beneficial effects of physical activity on children's body composition (Fogelholm, 2010), cardiovascular fitness (Freedman et al., 2007), bone health (Nikander et al., 2010), and psychological well-being (Biddle and Asare, 2011) are well documented. Current physical activity guidelines encourage children to engage in 60 minutes moderate-to-vigorous physical activity (MVPA) per day (Department of Health, 2011), though research indicates that not only are children not meeting these guidelines (Hills et al., 2011), but they are insufficient for health-related benefits (Andersen et al., 2006). Moreover, Steele et al. (2010) suggest that children engage in up to several hours of sedentary behaviour on a daily basis. Increased risk of cardiometabolic disease is associated with paediatric obesity (Freedman et al., 2007), and low levels of physical activity and high sedentary behaviour are fundamental implicating factors due to their influence on energy balance. Despite evidence to suggest that obesity prevalence has plateaued in recent years within the United Kingdom (UK; Boddy et al., 2010) and internationally (Lissner et al., 2010; Rokholm et al., 2010), there is no evidence of a decline, and obesity levels still remain extremely high. Further, previous stable phases have been followed by further increases. Of concern, fitness, a product of physical activity and an independent risk factor for chronic disease (Andersen et al., 2006), has declined in children independent of changes in body size (Stratton et al., 2007). Interventions to increase children's physical activity levels are therefore crucial to help form life-long healthy behaviours, especially as obesity (Lloyd et al., 2010) and fitness (Boreham et al., 2004), as well as physical activity (Craigie et al., 2011), track from childhood into adulthood.

Interventions to increase children's physical activity levels have been conducted with varied success (Summerbell et al., 2005). Moreover, interventions have endeavoured to decrease the prevalence of childhood overweight and obesity through single or holistic approaches to increase physical activity levels, decrease sedentary behaviour and enhance healthy eating. It has been advocated in a recent systematic review that 45% of interventions combining both physical activity and healthy eating components demonstrated significant intervention effects on body mass index (BMI), in comparison to 33% when either physical activity or healthy eating were addressed on their own (Brown and Summerbell, 2009). However, the effectiveness of combined healthy eating and physical activity interventions is equivocal (Brown and Summerbell, 2009). Varied success may be due to failure of analyses to account for relevant cofounders and clustering in analyses (van Sluijs et al., 2007), and lack of objective physical activity measurement (Mountjoy et al., 2011). These weaknesses aside, it is suggested that curriculum-based approaches to health promotion are effective (i.e., Gorely et al., 2009b; Naylor and McKay, 2009) when interventions combine physical activity and nutritional components, using established behaviour change and social support processes (Greaves et al., 2011; Kriemler et al., 2011; van Sluijs et al., 2007).

Schools are generally considered ideal settings for interventions promoting physical activity and healthy eating for several reasons, such as the ease of repeated access to a large number of children, the somewhat controlled environment of the school, and the general lack of cost (NICE, 2009; Fitzgibbon et al., 2005; Naylor and McKay, 2009). In England, children attend a primary school up to the age of 11, where they usually have one class teacher for all subjects, allowing for cross-curricular activities. It is postulated that sustainable healthy lifestyle interventions may be better implemented if built into school curricula and taught by existing school personnel in 'real life' conditions (i.e., without researcher support and resources; De Bourdeaudhuij et al., 2011). An appropriate setting for healthy lifestyle promotion is through interdisciplinary curriculum areas such as Personal, Social, and Health Education (PSHE).

Schools also enable interventions to engage families across the social spectrum (Lloyd et al., 2011), which is important as children typically engage in less physical activity and consume unhealthy foods when at home compared to when at school (Duncan et al., 2011). This consensus is in agreement with recent research stating that children are less active at weekends compared to weekdays when they are at school (Fairclough et al., 2012b), and their dietary intake is predominantly consumed at home (Regan et al., 2008), with decisions about food choices largely influenced by parents (Holsten et al., 2012). It is therefore unsurprising that some form of parental and/or family involvement is suggested to enhance the effectiveness of school-based interventions beyond the school environment (Pearson et al., 2009; van Sluijs et al., 2007).

The Children's Health, Activity and Nutrition: Get Educated! (CHANGE!) project targets physical activity and healthy eating through a school-based curriculum intervention delivered by in-service teachers and supported by family-based homework tasks. This approach has previously been utilised in the USA with some degree of success through programmes such as Planet Health (Gortmaker et al., 1999b). Therefore, the aim of this study was to assess the effect of the CHANGE! school-based physical activity and healthy eating intervention on habitual physical activity and body size in 10-11 year old children. Primary outcome variables are overall moderate physical activity (MPA), vigorous physical activity (VPA), MVPA and sedentary behaviour.

5.2: Methods

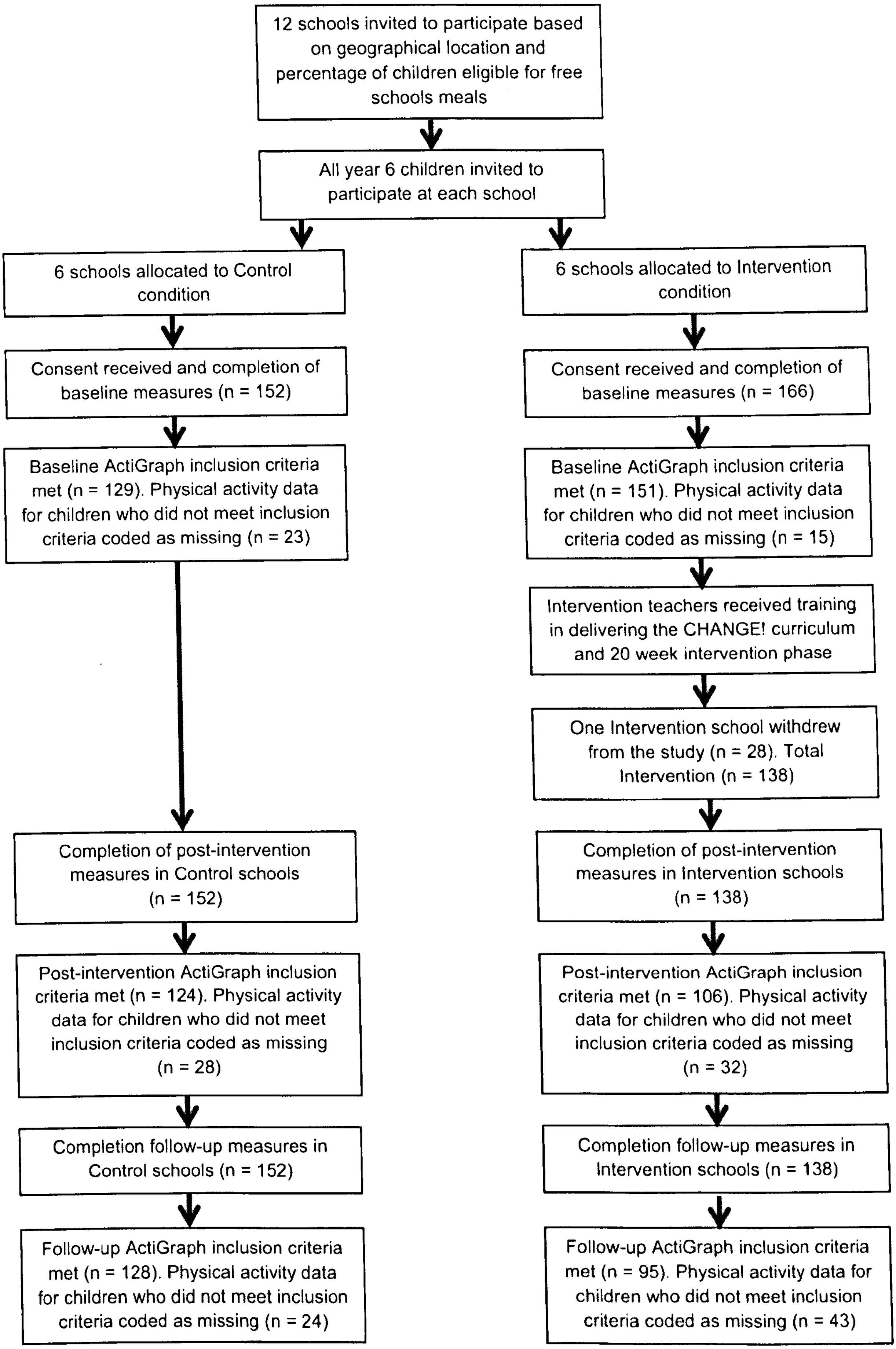
Participants and Settings.

The CHANGE! pilot study was a clustered randomised controlled trial (RCT). Twelve primary schools from the Wigan Borough in north-west England, a large municipal borough with a population of over 300,000, which is recognised as an area of high deprivation and health inequalities (Wigan Borough Partnership, 2007), were recruited to participate. The schools were clustered within pre-defined geographical areas known as Neighbourhood Management Areas (NMA), and stratified by the percentage of students per school eligible to receive free school meals, which was used as a measure of school-level socio-economic status (SES). One high and one low SES school per NMA were randomly selected to take part to ensure representation of the diverse geographical and social contexts present within the locale. The primary outcome measure for this study was MVPA, and body size (i.e., waist circumference, BMI, and BMI SDS) were secondary outcomes. As no robust minimum clinically important difference (MCID) anchors exist in the current literature for children's MVPA, Cohen's D values (Cohen, 1988) were used to anchor the power calculation. An a priori power calculation was completed. On the basis of a medium effect size (0.5) using a 2 tailed t-test with an alpha value of 0.05, 105 participants would be required in each group (total 210) to detect a difference at 0.95 power. The research team estimated a 20% participant attrition rate, therefore the target sample size was 252 (i.e., 126 per group). In each school all children within Year 6 (10-11.9 years) were invited to take part in the study (N=420), and written informed parental consent and participant assent were received from 318 children (75.7% participation rate; Control n = 129, Intervention n = 151). Approximately 95% of the children were of white British ethnicity, which is representative of the school age population in Wigan (Wigan Council, 2011).

Study Design.

The 12 schools were randomised using a random number generator, to an Intervention (N = 6 schools) or Control condition. Randomisation occurred prior to baseline measures to allow training to take place in Intervention schools and for teachers there to familiarise themselves with the curriculum intervention. Measures were completed at baseline, post-intervention (20 school weeks), and at a 10 week follow-up (prior to the school summer holidays). Ethical approval was granted by the local institutional ethics committee. Full details of the flow of schools and participants through the study are provided in Figure 5.1.

Figure 5.1. Flowchart depicting sample sizes from baseline to follow-up



Intervention.

The CHANGE! project is a school-based physical activity and healthy eating intervention study which is delivered through the PSHE strand of the primary school curriculum and complements the National Healthy Schools programme. The project aimed to promote healthy body size by targeting improvements in habitual MVPA, eating behaviours, and reducing sedentary time. Specifically, the programme aimed to increase MVPA and decrease sedentary behaviour through learning about making small behaviour changes which can lead to healthy lifestyles and encourage children to reflect on their own activity levels. The intervention design and content were informed by formative work conducted with parents, children, and teachers in the year prior to intervention commencement (Chapter 3; Mackintosh et al., 2011). The CHANGE! curriculum was adapted from existing resources that have been successfully implemented in the USA (Gortmaker et al., 1999b) and UK (Kipping et al., 2010; Kipping et al., 2008; Kipping et al., 2011), and which were designed for interdisciplinary curricula (Gortmaker et al., 1999b). The PSHE curriculum in English primary schools is structured in an interdisciplinary manner with relevant topics delivered collectively within particular themes (e.g., physical activity and nutrition topics taught within a 'healthy lifestyles' theme). With the permission of the publishers, modifications were made to the language, guidelines for healthy eating and physical activity, and reference to local contexts. Year 6 class teachers from the intervention schools received 4 hours of training in the delivery of the curriculum resource, and so were familiarised with the curriculum prior to implementation. The curriculum was designed to be as flexible as possible and teachers could decide when and how they used the material provided. The CHANGE! curriculum resource was a 305 page manual that consisted of 20 weekly lesson plans including worksheets and a CD-ROM, which were supplemented by homework tasks targeting family involvement in food and physical activity related tasks. The lessons provided an opportunity for children to discuss, explore, and understand the meaning and practicalities of healthy lifestyles. Homework tasks supplemented classroom work as recent evidence suggests that homework may be an effective means of promoting family involvement in physical activity and positive nutritional behaviours (Duncan et al., 2011). Table 5.1 displays the physical activity CHANGE! themes, lesson titles and lesson content summaries. The CHANGE! topics were aligned with the UK Healthy Schools programme and were cross-referenced to English National Curriculum objectives in Physical Education, Science, Mathematics, English, Information Technology, History, Geography, and PSHE. The control schools continued with their usual curriculum which followed National Curriculum Key Stage 2 programmes of study (Department of Education, 2011).

Table 5.1 CHANGE! themes, lesson titles and content summary

Theme	Lesson titles	Content summary
Introduction	Healthy Living	Lifestyle options, choices and consequences
Introduction: what is physical activity and where do we do it?	Map Maker	Physical activity definitions, intensities, guidelines for health, opportunities in local environment [mapping], types of activities
Monitoring and goal setting	Go for Goal	Simple monitoring of physical activity [diary/pedometer], goal setting principles
Reducing sedentary time	Power Down Impact of Technology	Identifying sedentary behaviours, when they occur, how technology has changed our lifestyles, goal setting for reducing screen time
Components of fitness	Muscle Mysteries The Human Heart	Simplify the concept of fitness as representing 'heart health', 'muscle health', 'body composition'; incorporate FITT principle as means of enhancing fitness, basic physiological principles to demonstrate effects of physical activity on body [e.g., pulse rate, etc.]
Energy balance	Keeping the Balance	Fuel; intake; expenditure; balance; negative/ positive; monitoring; nutrient functions and sources
Carbohydrate	Carb Smart	Types; processing; starchy foods; why important; fibre; good sources

Sugar	Sugar Water Beverage Buzz	Terminology & types; requirement; labels; sources - hidden; amounts; added sugar; consumption calculations
Fat	Hunting Hidden Fat	Terminology & types; requirement; labels (graphing activity); sources; effect of cooking; fish oils
Fruit & vegetables	Menu Monitoring	Benefits (source of variety of nutrients); portions; preparation; variety, storage; cooking; access; other foods containing fruit & vegetables, menu planning
Breakfast	Brilliant Breakfast	Benefits (energy); portions; choices; sugar; salt; nutritional comparison of different types of breakfast
Snacks (fats/sugar/salt)	Snack Attack Snack Decisions	Frequency of eating; swaps; snacks at bedtime; requirements; hidden sources of fat/sugar/salt; amounts
Variety	Balancing Act Keeping the Balance	Why variety needed; balanced diet & Eatwell Plate; nutrient functions and sources; food swaps; access; monitoring task
Awareness	Foods Around the World	Food production – growing; local specialities; history; access; food miles; mapping locality
Summary	Have You CHANGE!'d?	Summary of principles of healthy living

Measures.

Habitual Physical Activity.

Physical activity was objectively assessed for 7 consecutive days using ActiGraph accelerometers (GT1M, ActiGraph LLC, Pensacola, FL). Accelerometers are motion sensors that capture information regarding the intensity, frequency and duration of physical activity (Rowlands et al., 2006; Welk, 1999). Acceleration is defined as the change in velocity over time; therefore accelerometers assess physical activity through the body's acceleration (Corder et al., 2008; Freedson et al., 2005). The GT1M ActiGraph is a small and lightweight (3.8 x 3.7 x 1.8 cm, 27g) uni-axial accelerometer that measures vertical accelerations and deceleration between the magnitudes of 0.05-2.00g. It is a common tool used to assess the volume and intensity of physical activity, which has been previously validated with children (Ekelund et al., 2001; Trost et al., 1998). The GT1M ActiGraph is therefore relatively unobtrusive and practical, and has the ability to store large amounts of data (Freedson et al., 2005; Nilsson et al., 2002). Additionally, Dale et al. (2000) suggest that the ActiGraph has good potential for documenting the natural physical activity patterns of children. However, accelerometers are limited by their capacity to assess static physical activities, non-weight-bearing activities that require little body movement like cycling and do not accurately capture certain terrain changes such as gradient (Corbin et al., 2004; Trost et al., 2002). The accelerometer enables the monitoring of human motion (frequency and intensity), to be filtered and converted to a numerical value (counts) and these counts are subsequently summed over a specified time interval (epoch), which is specified prior to commencement of data collection upon initialisation of the devices (Baquet et al., 2007). The recorded counts for each epoch represents the intensity of the activity undertaken during that time period. At the end of each epoch, the summed value is stored in the memory and the ActiGraph is automatically reset to zero (Tryon and Williams, 1996). In this study, a 5 second epoch was used to collect the raw physical activity data to account for the sporadic nature of children's physical activity (McClain et al., 2008), which includes very short bursts of intense physical activity interspersed with varying intervals of low and moderate intensity activity (Bailey et al., 1995; Rowlands et al., 2008). In addition, shorter epochs have been advocated to provide a more detailed picture of children's physical activity patterns (Nilsson et al., 2002).

At each monitoring period participants were familiarised with ActiGraph on the first day and provided with the same accelerometer. The children were instructed to wear the ActiGraph over the right hip (anterior to the iliac crest) using a waist mounted nylon belt. To maximise the quality of the data, strategies were employed to encourage compliance. Students were given simple written and verbal instructions to wear the monitor over their right hip, making sure the belt was tight enough to stop the monitors from moving around but not so tight to make it uncomfortable, and to wear it all day from waking up to bedtime only removing the monitor for sleeping, bathing, showering, swimming, and any contact sports (i.e., rugby and martial arts). The children were directed to go about their normal activities whist wearing the monitor and were informed that they could wear it on the inside or outside of their clothes. The researcher also demonstrated how to wear the device properly and reminded the students of the importance not to forget to wear the monitor. As an incentive to promote compliance students were told that the child in each class who wore their accelerometer for most time averaged over the week would receive a CHANGE! T-shirt. In addition, to distinguish between wear time and sleep time children also completed a log sheet to record when the ActiGraph was put on in the morning and removed at night before bed, and any other times when the monitor was removed (e.g., during showering, contact sports, swimming etc.). These log sheets were checked and initialled by parents at the end of each day.

At the end of the data collection period ActiGraphs were collected from the children at school and downloaded using ActiLife v5.8.3 software (ActiGraph LLC, Pensacola, FL). This produced individual files, linked according to participant, containing movement counts recorded at every 5 second interval. Downloaded files were initially checked for compliance to the monitoring protocol using customised software (MeterPlus v4.2, Santech Inc., San Diego, CA; www.meterplussoftware.com). Sustained 20 minute periods of zero counts indicated that the ActiGraph had been removed, and total 'missing' counts for those periods represented the duration that monitors were not worn (Catellier et al., 2006), and subsequently removed from the final calculation of daily registered time (i.e., wear time). Completed log sheets of children were inspected to identify when the ActiGraphs had been removed for legitimate reasons due to participation in water-based activities or contact sports. To reduce the risk of unnecessarily excluding children from the analyses, where appropriate, daily wear time was manually adjusted upwards to include the time when the ActiGraphs had legitimately been removed. Children were included in the data analysis if they wore the monitors for at least 540 minutes on week days (Graves et al., 2011) and 480 minutes on weekend days (Nielsen et al., 2012; Rowlands et al., 2008) for a minimum of 3 days (Nielsen et al., 2012). These inclusion criteria have previously shown acceptable reliability in similarly aged children (Mattocks et al., 2008). Specifically, 540 minutes of weekday inclusion criteria have demonstrated reasonable reliability (r = 0.7) and power (91.7%) to detect a significant difference in physical activity (counts•min^{-1}) between two groups (Mattocks et al., 2008). At baseline 38 participants (23 Control, 15 Intervention) did not meet these criteria, followed by 60 at post-intervention (28 Control, 32 Intervention), and 67 at follow-up (24 Control, 43 Intervention). These participants' physical activity data were coded as missing. Habitual physical activity is typically analysed using activity count thresholds generated from validated regression equations, however great variation exists in established thresholds for different activity intensities. (i.e., between 906 (Trost et al., 2002) to 3200 counts•min^{-1} (Puyau et al., 2002) for moderate intensity physical activity). As there is no consensus as to which ActiGraph cut-points are the most appropriate in diverse paediatric populations, a sub-study was conducted which generated population-specific accelerometer cut-points of 2160 counts•min^{-1} for MPA and 4806 counts•min^{-1} for VPA (Chapter 4; Mackintosh et al., 2012). These cut-points were appropriate to the age group of interest and demonstrated similar agreement classification as those reported by Evenson et al. (2008) which were recently highlighted as demonstrating acceptable classification accuracy at moderate and vigorous activity intensities (Trost et al., 2011). Further, these cut-points were subsequently cross-validated with selected physical and sedentary activities. For sedentary time a cut-point of 100 counts•min^{-1} was used (Trost et al., 2011). Total physical activity (TPA) was presented in counts•min^{-1} and daily time spent in MPA, VPA, and MVPA, as well as sedentary time (SED) were calculated and presented as mins•day^{-1}.

Furthermore, sedentary time and MVPA were ranked and stratified into tertiles, with the upper and lower tertiles representing high and low sedentary and MVPA groups, respectively.

There is increasing interest in examining children's physical activity on both weekdays and weekend days. Children have been shown to be less active at weekends (Fairclough et al., 2012b; Uvacsek et al., 2011), with a suggested reason being the lack of structured school environment in conjunction with its regular opportunities for physical activity (Treuth et al., 2007). Moreover, research indicates that children engage in prolonged sedentary behaviour at weekends (Biddle et al., 2009). Even further, the majority MVPA children engage in during a weekday is accumulated at school (Fairclough et al., 2008; Guinhouya et al., 2009a). To this end, physical activity data was also analysed for weekend, weekday, and school and non-school time for weekdays.

Anthropometry.

Measurements of stature, sitting stature and body mass were taken using standardised procedures. Students were measured without footwear whilst wearing minimal school uniform (i.e., trousers/skirt, shirt).

Stature.

Measurements of stature were recorded using a portable stadiometer (Seca Ltd., Birmingham, UK). Students were asked to stand upright against the stadiometer and the vertical distance between the floor and the highest point of the skull was measured and recorded to the nearest 0.1 cm. The researcher ensured the students' head remained level and they were asked to breathe in when measured. The described procedure conforms to standard techniques (Lohman et al., 1988).

Sitting Stature.

Measurements of sitting stature were recorded using a portable stadiometer (Seca Ltd., Birmingham, UK). Students were asked to sit on the floor at the base of the stadiometer, with their legs slightly bent out in front of them, whilst keeping their back straight. Measurements of the vertical distance between the floor and the highest point of the skull was measured and recorded to the nearest 0.1 cm. The researcher ensured the student's head remained level and they were asked to breathe in when measured. Leg length was then calculated by subtracting sitting stature from stature.

Waist Circumference.

Waist circumference was measured using a non-elastic anthropometric tape and measurements were taken at the narrowest point between the bottom of the ribs and the iliac crest by one researcher. Two measurements were taken, with a third being required if the first two measurement differed by more than 0.4 cm (Mirwald et al., 2002). The mean of the two measurements was calculated, but if three measurements were taken, the median value was used.

Body Mass.

Measurements of body mass were recorded using calibrated scales (Seca Ltd., Birmingham, UK) to the nearest 0.1 kg.

Body Mass Index (BMI).

Body mass index was calculated (body mass (kg) / stature^2 (m^2)) and BMI z-scores (BMI SDS) were assigned to each participant. Body mass index is used as an estimation of overweight and obesity prevalence in child populations (Chinn and Rona, 2001).

Weight status.

International Obesity Task Force age and sex-specific BMI cut-points (Cole et al., 2000) were used to classify children as either normal-weight (NW) or overweight/obese (OW).

Maturity Status.

Somatic maturity was estimated according to Mirwald et al.'s (2002) maturity offset sex-specific regression equations. These equations determine years from attainment of peak height velocity (PHV), which is a common technique used in longitudinal studies (Malina et al., 2004). This non-invasive method has been used previously in similar aged children (Fairclough and Ridgers, 2010). The maturity offset equations are as follows:

Boys Maturity Offset = -9.236 + 0.0002708·Leg Length and Sitting Stature Interaction - 0.001663·Age and Leg Length Interaction + 0.007216·Age and Sitting Stature Interaction + 0.02292·Weight by Height Ratio

Girls Maturity Offset = -9.376 + 0.0001882·Leg Length and Sitting Stature Interaction + 0.0022·Age and Leg Length Interaction + 0.005841·Age and Sitting Stature Interaction - 0.002658·Age and Weight Interaction + 0.07693·Weight by Height Ratio

A negative value indicated the number of years before the age at PHV, and a positive value indicated the number of years a participant was beyond the age at PHV.

Socio-economic Status (SES).

Socio-economic status was calculated using the 2010 Indices of Multiple Deprivation (IMD) which are a composite of seven domains of deprivation (income, employment, education, health, crime, access to services, and living environment) (Department for Communities and Local Government, 2008). Indices of Multiple Deprivation scores were generated from students' home postcodes, which were uploaded to the GeoConvert applications (MIMAS, 2011) to locate raw and ranked IMD scores from the National Statistics Postcode Directory database (National Statistics Postcode Directory, 2010). Higher scores represent higher degrees of deprivation. Indices of Multiple

Deprivation scores were ranked and stratified into tertiles. The upper and lower tertiles represented low and high SES groups, respectively.

20m Multi-Stage Shuttle Runs Test (20mSRT).

Cardiorespiratory fitness (CRF) was tested using the 20m multi-stage shuttle run test (20mSRT). This test provides an estimate of CRF and has been widely used in children of a similar age in the past (Stratton et al., 2007; van Mechelen et al., 1986). Total number of completed shuttles was used as a CRF marker.

Environmental Variables.

The number of children enrolled in each school was recorded. Aerial views of the schools' playground areas were located using the Google™ Earth Pro (GEP) application (version 6.1.0.4738) to quantify available outdoor spatial areas for physical activity participation. The GEP application has been used previously in geo-coding studies (Lovasi et al., 2007) and provides a simple cost-effective means of quantifying spatial areas. Accessible and usable spatial areas for activity (playground areas) were identified by teachers and calculated using the GEP polygon tool. The area of each of the polygons was calculated by the software and the recorded and summed for each school to provide an estimate of total playground spatial area (Ridgers et al., 2010b). This approach has been used in recent youth physical activity research (Fairclough et al., 2012b). During the data collection period daily temperature and average daily rainfall were recorded (Met Office, 2009).

Statistical Analysis.

In addition to the children who failed to meet ActiGraph inclusion criteria, one Intervention school withdrew from the study early in the intervention phase (28 participants), giving a 35.5% and 51.9% attrition rate at post-intervention, and follow-up, respectively and a final sample size of 153 (Control n = 83; Intervention n = 70) (Figure 5.1).

Preliminary ANOVAs and Friedman tests were completed to assess between and within group differences at baseline, post-intervention, and follow-up. In the social world, many data have an inherent hierarchical structure that can affect them (Kreft and De Leeuw, 1998). For example, a person's behaviour can be explained by taking into account the context, such as class, school, or organisation. To account for the time-related and nested nature of the student data within the 12 schools, multilevel modelling was performed for the main analyses to determine the effects of the intervention. This technique is an extension of ordinary multiple regression and is considered as the most appropriate analysis method with nested designs (Goldstein, 1995). Multilevel models can analyse the hierarchical nature of non-independent, nested data (e.g., students nested within schools) by taking into account the dependency of observations, building upon single level regression analyses (Goldstein, 1995). To account for the outcome measures from different time points being nested in students, who were nested in schools, a 3-level data structure was initially used. School was included as a third level unit to control for the effect that this particular context could have on the children's behaviours (Twisk, 2006). That is, this approach takes into account the hierarchy among participants that exists because individuals (i.e., students) within a school are more like each other than individuals between schools. Timing of the post-intervention and follow-up measurements were defined as the first level unit of analysis, students were the second level unit, and schools were the third level unit of analysis.

Analyses were performed using a 'long' data structure in MLwiN 2.24 software (Centre for Multilevel Modelling, University of Bristol, UK). Association models were used to assess the average effects of the CHANGE! intervention on the outcome variables over the post-intervention and follow-up time points (Ridgers et al., 2010a; Ridgers et al., 2007), after being adjusted for potentially confounding variables. Outcome variables were BMI, BMI SDS (Cole et al., 1995), waist circumference, TPA, MPA, VPA, MVPA, and sedentary time. Further, weekday (school and non-school hours) and weekend day physical activity (i.e., MPA, VPA, MVPA, and SED) were also outcome variables. To estimate the average effect of the intervention on the outcome measures, potential confounding variables based on previous research (Fairclough et al., 2009; Fairclough and Ridgers, 2010; Ridgers et al., 2010a; Ridgers et al., 2011) were added to the models as they may influence the change in the magnitude of the intervention effect (Twisk, 2006). Time (post-intervention, follow-up) was used to account for the measures being conducted on different occasions. Depending on the outcome variable, student level covariates included baseline outcome variable values, sex, maturity offset (years from PHV), 20mSRT performance, ActiGraph wear time, SES groups (high or low), and weight status (normal weight or overweight/obese). School level covariates also differed slightly depending on the outcome variable, and included number of students enrolled in the school, playground area per student, and average daily temperature and average daily rainfall during the week of physical activity monitoring. The intervention term was constructed using a dummy variable, where '0' indicated control group schools and '1' indicated intervention schools. 'Adjusted' analyses were conducted for all outcome variables controlling for baseline outcome values and all respective covariates to investigate the intervention effect (Twisk, 2006).

Potential effect modification was also assessed for dichotomous covariates (i.e., time, sex, weight status group, sedentary group, MVPA group, and SES group) to investigate whether intervention effects differed for different subgroups. This was assessed by constructing interaction terms between the intervention effect and the covariates. Interaction terms were added separately to the analyses to determine their influence on the effect of the intervention (Twisk, 2006). The effect of the predictor variables on each outcome variable in the main and interaction models were assessed for significances by comparing the log likelihood for each model on the Chi-square distribution with 1 degree of freedom and regression coefficients were assessed for significance using the Wald statistic (Twisk, 2006). The Wald statistic is calculated using the following equation: Wald statistic = $(\text{Regression Coefficient/Standard Error})^2$. Participants were included in the analyses regardless of missing data which was accounted for in the multilevel models. All analyses were conducted on an intention-to-treat basis. Statistical significance was set at $p<0.05$, and at $p<0.1$ for interaction terms as they have less power (Twisk, 2006).

5.3: Results

Preliminary Results.

Descriptive characteristics of the participants are presented in Table 5.2. There were no significant between group differences. Girls were heavier ($p<0.05$) and more somatically mature ($p<0.001$) than boys at each time point, for the control group, and both groups, respectively.

Table 5.3 describes unadjusted outcome measures at baseline, post-intervention, and follow-up for physical activity. The Intervention children engaged in significantly more TPA ($p<0.01$), MPA ($p<0.01$), VPA ($p<0.05$), and MVPA ($p<0.001$) at baseline, and MVPA post-intervention ($p<0.05$). Boys spent more time in TPA, MPA, VPA, and MVPA than girls at each time point ($p<0.001$). Significantly more Intervention than Control children achieved recommended guidelines of at least 60 minutes MVPA per day at baseline (54.1% vs. 33.6%, $p<0.01$) but values were similar at post-intervention (Control = 47.6%, Intervention = 55.7%), and follow-up (Control = 55.1%, Intervention = 57.9%). The increase in the percentage of Control children achieving these guidelines was significant at each time point ($p<0.05$). The Control group accrued most sedentary time post-intervention ($p<0.05$) and at follow-up ($p<0.001$). Table 5.4 describes unadjusted outcome measures at baseline, post-intervention, and follow-up for body size. Overall, girls' BMI values were significantly higher than boys at each time point ($p<0.05$), and significantly more girls than boys were categorised as OW at baseline ($p<0.01$) and follow-up ($p<0.05$). Waist circumference was greater among Control group children at post-intervention and follow-up than Intervention children ($p<0.05$).

Table 5.2. Descriptive characteristics of Control and Intervention children at baseline, post-intervention, and follow-up (Mean ± SD)

		Control						Intervention					
		Baseline		Post-intervention		Follow-up		Baseline		Post-intervention		Follow-up	
Measure	Sex	n	Value	n	Value	n	Value	n	Value	n	Value	n	Value
Age (years)	Boy	69	10.7 ± 0.3	69	11.0 ± 0.3	69	11.2 ± 0.3	79	10.6 ± 0.3	65	11.1 ± 0.3	65	11.3 ± 0.3
	Girl	83	10.7 ± 0.3	83	11.0 ± 0.3	83	11.2 ± 0.3	87	10.6 ± 0.3	73	11.1 ± 0.3	73	11.3 ± 0.3
	All	152	10.7 ± 0.3	152	11.0 ± 0.3	152	11.2 ± 0.3	166	10.6 ± 0.3	138	11.1 ± 0.3	138	11.3 ± 0.3
Stature (m)	Boy	69	1.4 ± 0.1	69	1.5 ± 0.1	69	1.5 ± 0.1	79	1.4 ± 0.1	65	1.5 ± 0.1	63	1.5 ± 0.1
	Girl	83	1.5 ± 0.1	82	1.5 ± 0.1	82	1.5 ± 0.1	86	1.4 ± 0.1	68	1.5 ± 0.1	67	1.5 ± 0.1
	All	152	1.4 ± 0.1	151	1.5 ± 0.1	151	1.5 ± 0.1	165	1.4 ± 0.1	133	1.5 ± 0.1	130	1.5 ± 0.1
Body mass (kg)	Boy	69	35.3 ± 7.9	69	37.0 ± 8.0	69	37.1 ± 8.0	79	35.7 ± 6.3	65	37.9 ± 6.9	63	37.5 ± 6.5
	Girl	83	39.9 ± 11.1	82	42.8 ± 12.1	82	42.6 ± 12.2	85	36.1 ± 9.0	68	39.0 ± 9.4	66	39.3 ± 9.9
	All	152	38.1 ± 10.2	151	40.6 ± 11.1	151	40.4 ± 11.0	164	36.2 ± 7.9	133	38.5 ± 8.3	129	38.5 ± 8.6
Maturity offset (years from PHV)	Boy	69	-3.1 ± 0.4	69	-3.1 ± 0.4	69	-2.7 ± 0.4	78	-3.0 ± 0.4	65	-2.8 ± 0.4	63	-2.7 ± 0.4
	Girl	83	-1.3 ± 0.6	82	-1.0 ± 0.6	82	-0.8 ± 0.6	85	-1.4 ± 0.6	68	-1.0 ± 0.6	65	-0.8 ± 0.6
	All	152	-2.0 ± 1.1	151	-1.8 ± 1.2	151	-1.5 ± 1.1	163	-2.1 ± 1.0	133	-1.8 ± 1.0	128	-1.6 ± 1.1
IMD score	Boy	69	26.0 ± 15.0	69	26.0 ± 15.0	69	26.0 ± 15.0	79	27.2 ± 18.0	79	27.2 ± 18.0	79	27.2 ± 18.0
	Girl	83	23.1 ± 13.8	83	23.1 ± 13.8	83	23.1 ± 13.8	87	30.7 ± 18.9	87	30.7 ± 18.9	87	30.7 ± 18.9
	All	152	24.2 ±14.3	152	24.2 ± 14.3	152	24.2 ± 14.3	166	29.2 ± 18.5	166	29.2 ± 18.5	166	29.2 ± 18.5

Table 5.3. Unadjusted physical activity outcome measures of Control and Intervention children at baseline, post-intervention, and follow-up (Mean ± SD)

		Control			Intervention		
Measure	Sex	Baseline	Post-Intervention	Follow-up	Baseline	Post-Intervention	Follow-up
TPA	Boy	587.7 ± 160.2	597.1 ± 145.6	630.7 ± 177.3	667.5 ± 177.4	648.1 ± 226.0	669.6 ± 186.5
(counts•min^{-1})	Girl	461.7 ± 92.7	501.6 ± 126.8	539.6 ± 144.7	556.5 ± 198.6	529.5 ± 167.0	540.0 ± 168.3
	All	502.3 ± 131.9	532.4 ± 139.8	569.0 ± 160.8	601.5 ± 196.9	577.6 ± 200.5	592.4 ± 186.1
MPA	Boy	51.9 ± 11.5	50.0 ± 10.9	58.8 ± 20.4	57.9 ± 13.90	52.1 ± 13.8	59.5 ± 18.4
(mins•day^{-1})	Girl	38.1 ± 9.2	40.5 ± 10.0	44.2 ± 12.5	42.32 ± 11.6	41.5 ± 13.5	42.9 ± 12.4
	All	42.6 ± 11.9	43.6 ± 11.2	48.9 ± 16.9	48.6 ± 14.7	45.7 ± 14.5	49.6 ± 17.1
VPA	Boy	19.2 ± 10.3	18.1 ± 8.5	20.9 ± 11.2	21.4 ± 9.3	21.4 ± 13.1	20.7 ± 10.5
(mins•day^{-1})	Girl	11.3 ± 5.10	13.1 ± 6.5	13.4 ± 6.2	14.6 ± 8.2	13.7 ± 7.0	13.4 ± 6.5
	All	13.8 ± 8.1	14.7 ± 7.5	15.7 ± 8.2	17.3 ± 9.3	16.8 ± 10.6	16.5 ± 9.6
MVPA	Boy	71.2 ± 20.4	68.1 ± 17.8	79.3 ± 28.4	79.2 ± 20.1	73.5 ± 23.9	80.4 ± 26.1
(mins•day^{-1})	Girl	49.4 ± 12.3	53.6 ± 14.5	57.6 ± 15.9	56.9 ± 16.8	55.2 ± 18.1	56.3 ± 15.3
	All	56.4 ± 18.4	58.2 ± 17.0	64.6 ± 23.0	65.9 ± 21.2	62.2 ± 19.7	66.1 ± 23.5
Sedentary time	Boy	512.4 ± 64.1	510.3 ± 104.0	481.1 ± 134.7	511.2 ± 70.0	488.6 ± 106.2	511.1 ± 112.5
(mins•day^{-1})	Girl	521.7 ± 59.1	503.8 ± 104.9	498.7 ± 112.0	503.1 ± 56.9	480.3 ± 139.3	495.1 ± 91.2
	All	517.4 ± 61.4	506.8 ± 104.1	490.6 ± 122.7	506.6 ± 62.9	484.0 ± 125.2	502.2 ± 101.1

Table 5.4. Unadjusted body size outcome measures of Control and Intervention children at baseline, post-intervention, and follow-up (Mean ± SD except weight status)

		Control						Intervention					
		Baseline		Post-intervention		Follow-up		Baseline		Post-intervention		Follow-up	
Measure	Sex	n	Value	n	Value	n	Value	n	Value	n	Value	n	Value
BMI (kg/m^2)	Boy	69	17.0 ± 2.9	69	17.1 ± 2.8	69	17.4 ± 2.8	79	17.5 ± 2.4	65	18.0 ± 2.7	63	17.5 ± 2.3
	Girl	83	18.8 ± 4.0	82	19.3 ± 4.1	82	19.5 ± 4.2	85	18.1 ± 3.4	68	18.3 ± 3.4	66	18.1 ± 3.4
	All	152	18.1 ± 3.7	151	18.5 ± 3.8	151	18.7 ± 3.9	164	17.9 ± 3.0	133	18.2 ± 3.1	129	17.8 ± 2.9
Weight status													
Normal weight (%)	Boy	69	82.6	69	82.6	69	84.1	79	88.6	65	86.2	63	90.5
	Girl	83	74.7	82	73.2	82	75.6	85	71.8	68	77.1	66	75.0
	All	152	78.3	151	77.5	151	79.5	164	79.9	133	81.5	129	82.4
Overweight/ Obese (%)	Boy	69	17.4	69	17.4	69	15.9	79	11.4	65	13.8	63	9.5
	Girl	83	25.3	82	26.8	82	24.4	85	28.2	68	22.3	66	25.0
	All	152	21.7	151	22.5	151	20.5	164	20.1	133	18.5	129	17.6
BMI-SDS (kg/m^2)	Boy	69	-0.2 ± 1.4	69	-0.2 ± 1.4	69	-0.1 ± 1.3	79	0.2 ± 1.0	65	0.3 ± 1.1	63	0.1 ± 1.0
	Girl	83	0.3 ± 1.4	82	0.4 ± 1.3	82	0.4 ± 1.3	85	0.1 ± 1.3	68	0.1 ± 1.3	66	-0.1 ± 1.3
	All	152	0.1 ± 1.4	151	0.2 ± 1.4	151	0.2 ± 1.3	164	0.2 ± 1.1	133	1.2 ± 1.2	129	-0.02 ± 1.2
Waist circumference (cm)	Boy	68	60.7 ± 7.9	69	61.8 ± 7.2	69	61.4 ± 7.0	78	61.6 ± 6.1	65	60.7 ± 5.5	63	61.5 ± 5.7
	Girl	83	63.1 ± 9.1	82	64.8 ± 10.0	82	64.3 ± 9.6	86	61.3 ± 8.7	68	61.1 ± 8.3	67	61.5 ± 8.7
	All	151	62.2 ± 8.7	151	63.6 ± 9.1	151	63.2 ± 8.8	164	61.5 ± 7.6	133	60.9 ± 7.2	130	61.5 ± 7.5

Main Physical Activity and Sedentary Time Results. (Table 5.5)

Overall Physical Activity and Sedentary Time.

Intervention children spent on average 3.24 minutes per day more engaged in VPA than Control children ($p<0.05$) but there were no significant intervention effects for TPA, MPA, MVPA, or sedentary time. The Intervention children accumulated an average 11.81 more accelerometer counts•min^{-1}, but 3.46 minutes less MPA than Control group peers. Negligible differences in MVPA and sedentary time were observed between the two groups. 20m SRT performance was positively associated with VPA ($p<0.001$) and MVPA ($p<0.05$). A positive association was observed between playground space and VPA ($p<0.01$), while maturation was inversely associated with TPA ($p<0.05$) and positively associated with sedentary time ($p<0.01$). Accelerometer wear time was positively associated with MPA ($p<0.001$), VPA ($p<0.05$), MVPA ($p<0.001$), and sedentary time ($p<0.001$).

Weekday Physical Activity and Sedentary Time.

Intervention children accumulated on average 88.71 counts•min^{-1} more per day than Control children ($p<0.05$) but there were no significant intervention effects for MPA, VPA, MVPA or sedentary time. Playground area ($p<0.05$) and 20m SRT performance ($p<.001$) was positively associated with TPA, while years from PHV was inversely associated ($p<0.01$). The Intervention children engaged on average 2.67, 5.46 and 8.04 minutes more than Control group peers for MPA, VPA and MVPA, respectively. Negligible differences in sedentary time were observed between the two groups. Playground area was positively associated with VPA ($p<0.01$) and MVPA ($p<0.05$). A positive association was observed between 20m SRT performance and MPA ($p<0.01$), VPA ($p<0.001$) and MVPA ($p<0.001$). Boys engaged in significantly more MPA (9.55 minutes; $p<0.05$) and MVPA (13.95 minutes; $p<0.05$) on weekdays, as well as more VPA (4.05 minutes) and less sedentary time (14.36 minutes), though these were not significant. Accelerometer wear time was positively associated with MPA ($p<0.001$), MVPA ($p<0.01$) and sedentary time ($p<0.001$).

Weekend Day Physical Activity and Sedentary Time.

There were no significant intervention effects for TPA, MPA, VPA, MVPA or sedentary time ($p>0.05$). Intervention children accumulated on average less TPA (62.56 counts•min^{-1}), MPA (8.74 minutes) and MVPA (5.68 minutes) per day than Control children, but more VPA (2.47 minutes) and sedentary time (7.99 minutes). Negligible differences in sedentary time were observed between the two groups. Accelerometer wear time was positively associated with MPA ($p<0.001$), VPA ($p<0.01$), MVPA ($p<0.001$) and sedentary time ($p<0.001$). There were no significant gender associations with physical activity intensities or sedentary time. Those children closer to reaching PHV engaged in more sedentary time and less TPA, though this finding was not significant.

School Time Physical Activity and Sedentary Time.

There were no significant intervention effects for MPA, VPA, MVPA or sedentary time ($p>0.05$). Intervention children engaged in on average 8.93 minutes less sedentary time. Negligible differences in MPA, VPA and MVPA were observed between the two groups, though VPA and MVPA were higher in the Intervention group. Weight status was negatively associated with VPA in school ($p<0.01$). Boys engaged in significantly more MPA ($P<0.001$) and VPA ($p<0.01$) compared to girls. Maturity status ($p<0.001$) and number of students enrolled ($p<0.01$) were positively associated with MVPA.

Out of School Time Weekday Physical Activity and Sedentary Time.

There were no significant intervention effects for MPA, VPA, MVPA or sedentary time ($p>0.05$). Intervention children engaged in on average 10.96 minutes more sedentary time, though this was not significant. Those children closer to reaching PHV engaged in more sedentary time and less MPA, VPA and MVPA, though not significant. 20m SRT performance was positively associated with MPA ($p<0.01$), VPA ($p<0.001$) and MVPA ($p<0.01$). A positive association was observed between low SES and MPA ($p<0.01$) and MVPA ($p<0.05$). Accelerometer wear time was positively associated with MPA, MVPA, and sedentary time ($p<0.001$).

Table 5.5. Multilevel model analyses of adjusted physical activity and sedentary time

	TPA (cpm)		MPA (min)		VPA (min)		MVPA (min)		SED (min)	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Overall										
Group†	11.81	56.02, 79.62	-3.46	-9.58, 2.58	**3.24***	0.06, 6.34	-0.01	-8.05, 8.03	13.71	-9.03, 36.44
Weekend Day										
Group†	-62.56	-201.82, 76.70	-8.74	-19.34, 1.86	2.47	-6.29, 11.23	-5.68	-20.46, 9.10	7.99	-24.57, 40.55
Weekday										
Overall Weekday										
Group†	**88.71***	14.09, 163.33	2.67	-50.3, 10.37	5.46	-0.95, 11.87	8.04	-3.58, 19.66	0.63	-22.58, 23.84
School Time										
Group†			-0.31	-3.78, 3.16	0.31	-1.90, 2.52	0.13	-4.12, 4.38	-8.93	-25.47, 7.61
Out of School Time										
Group†			-1.75	-6.34, 2.84	1.02	-3.37, 5.41	-1.02	-8.19, 6.15	10.96	-6.48, 28.40

†Reference category = Control group; The Intervention β values represent the estimated difference in physical activity outcomes for the Intervention schools against the Control schools when covariates are included in the final model. A positive β value (negative for sedentary time) indicates a positive intervention effect on the physical activity outcomes of the Intervention children compared with the Control school children.
* $p<0.05$, ** $p\leq0.01$, *** $p\leq0.001$

Body Size. (Table 5.6)

Waist circumference, BMI and BMI SDS were significantly reduced over time for both groups ($p<0.001$). A significant intervention effect was observed for waist circumference, with the Intervention children's values 1.75 cm less than the Control children's over time ($p<0.001$). Moreover, the Intervention children's BMI and BMI SDS were 0.33 kg/m^2 and 0.21 ($p<0.01$), respectively, less than the Control children's. Waist circumference was positively associated with maturation ($p<0.001$) and sex, with boys' values being 1.69 cm greater than girls' ($p<0.05$). Furthermore, significant positive associations were observed between body size and maturation (BMI SDS; $p<0.05$), 20m SRT performance (BMI, $p<0.001$; BMI SDS, $p<0.01$), and sex (boys > girls; BMI, $p<0.05$; BMI SDS, $p<0.01$). Children's waist circumference and BMI values continued to decrease at follow-up, though not significantly.

Table 5.6. Multilevel model analyses of adjusted body size outcomes

	Waist circumference (cm)		BMI (kg/m^2)		BMI SDS	
	β	95% CI	β	95% CI	β	95% CI
Group†	**-1.75 *****	-2.34, -1.16	-0.33	-0.68, 0.02	**-0.21****	-0.37, -0.05

†Reference category = Control group; The Intervention β values represent the estimated difference in body size outcomes for the Intervention schools against the Control schools when covariates are included in the final model. A negative β value indicates a positive intervention effect on the body size outcomes of the Intervention children compared with the Control school children. * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Interactions.

Physical Activity.

Interaction terms were observed between SES groups and TPA. The low SES Intervention children increased TPA by 89.45 counts•min^{-1} per day ($p<0.05$). For weekdays, similar interaction terms were observed between SES groups and TPA. Follow-up analyses indicated that the intervention effect was significant among the low SES group who accumulated 80.59 counts•min^{-1} more per weekday ($p<0.05$). Potential effect modification analyses revealed significant interaction terms between MVPA groups and school time sedentary time. Follow-up analyses indicated that the intervention effect was significant among the high MVPA Intervention children who reduced sedentary time by 25.27 minutes during school time ($p<0.05$).

Body Size.

Potential effect modification analyses revealed significant interaction terms between weight status and waist circumference. Follow-up analyses indicated that the intervention effect was significant among the NW children who reduced waist circumference by 0.84 cm ($p<0.01$), and the OW children whose waist circumference values were attenuated by 1.86 cm ($p<0.001$). Significant interaction terms were also identified between sex and BMI SDS. The adjusted interaction model showed a significant inverse intervention effect for girls (β = -0.23, p=0.01). Other BMI SDS interactions were found with between sedentary group and SES group. BMI SDS decreased by 0.31 among the high sedentary group ($p<0.01$) and by 0.29 among the low SES group ($p<0.01$). For BMI similar interaction terms were observed between sedentary and SES groups. The high sedentary children in the Intervention group decreased BMI by 0.48 kg/m^2 ($p<0.05$), while the low SES Intervention children's BMI reduced by 0.29 kg/m^2 ($p<0.01$).

5.4: Discussion

The CHANGE! intervention was effective in promoting VPA and, upon further analyses, weekday TPA. Intervention children engaged in significantly more VPA over time than Control children after receiving the CHANGE! intervention. The CHANGE! curriculum and homework tasks did not specifically target or promote VPA. Rather, interpretation of and decision making about physical activity intensity was left to the children, and in reference to the homework tasks, their families. The results indicate that the physical activity messages taught through the CHANGE! lessons may have been applied in practice by the children more in the form of vigorous (e.g., chasing games, informal and formal sports), rather than moderate intensity physical activity (e.g., walking). This may provide clues to how children interpret and understand educational messages about being physically active. Furthermore, for the least active, most sedentary, and overweight children, the findings may hint at why VPA is inhibited by physical limitations (e.g., low cardiorespiratory fitness; Parikh and Stratton, 2011), and psycho-social barriers (e.g., poor body image, low perceived PA competence; Fairclough et al., 2012a).

The increase in VPA observed in the study are in contrast to previous primary school-based interventions in the UK (Sahota et al., 2001a; Sahota et al., 2001b; Warren et al., 2003), which found no changes in physical activity. This suggests that the CHANGE! content was more effective. However, it must be considered that the use of an objective measure of physical activity, in addition to using comprehensive analyses accounting for potential confounders, provided greater sensitivity in the present study. Systematic reviews have reported that intervention studies employing objective measures are more likely to report significant positive results than studies using self-report measures (Salmon et al., 2007; van Sluijs et al., 2007). A recent primary school intervention study employing objectively measured physical activity found increases in MVPA and steps (Gorely et al., 2009b). CHANGE! data did not show an increase in MVPA in the Intervention children, however, the observed changes in VPA may be due to the sample-specific cut-points applied. It is postulated that previous research may have also found increases in VPA, which were not detected because the majority of research fails to report MPA and VPA separately (Brown and Summerbell, 2009; Kriemler et al., 2011), or the VPA cut-points were too low to detect change. It may be proposed that the higher VPA cut-points are more proficient in detecting a shift in physical activity intensity (Mattocks et al., 2007).

Changes in body size may be due to the significant increase in VPA. Recent research suggests that time spent in VPA is more strongly associated with adiposity than sedentary time or MVPA (Ekelund et al., 2004; Gutin, 2008; Ruiz et al., 2006; Steele et al., 2009; Wittmeier et al., 2008) and may confer greater benefits than MPA in relation to cardiovascular (Hopkins et al., 2009; Parikh and Stratton, 2011), musculoskeletal (Sardinha et al., 2008), and psychological health (Parfitt et al., 2009). The higher VPA cut-points employed in the present study provide promise for detecting health-related changes and support this contention. The positive association between number of 20m SRT shuttles completed and average minutes spent in VPA in the present study demonstrates that the fitter the children are, the longer they spend in vigorous intensity physical activity (Ortega et al., 2008). It is acknowledged, however, that the associated energy cost of VPA for children with lower CRF may be greater than for fitter peers (Spadano et al., 2003), which is supported by the significant positive association observed between body size and those children who completed less shuttles.

Although the schools were randomised to Intervention and Control conditions prior to baseline data collection there were differences of 6 minutes and 9.5 minutes in baseline MPA and MVPA, respectively. Baseline physical activity values were controlled in the analyses but the modest increases in MPA (2.1%) and MVPA (0.3%) observed among the Intervention children relative to the larger increases in the Control children (14.8% and 14.5%, respectively) were insufficient to cause significant effects over time. At baseline the Intervention children exceeded physical activity guidelines (Department of Health, 2011) and were substantially more active than the Controls. This may have created a high ceiling effect and therefore limited the scope of the Intervention children to increase physical activity (Corder et al., 2008; Oliver et al., 2006), even though the proportion of them meeting physical activity guidelines was maintained at follow-up. It is unclear why the Control group increased their physical activity over the duration of the study. Follow-up evaluation interviews with the Intervention teachers satisfied the researcher that CHANGE! resources had not been shared with the Control schools. Furthermore, it is unlikely that the Control schools adopted new physical activity or sport programmes that excluded the Intervention schools because such initiatives would be introduced simultaneously into all School Sports Partnership primary schools by the local School Sports Coordinator. Seasonal effects cannot be discounted though as post-intervention and follow-up measures occurred in the spring and summer months, following baseline assessments in October and November. Warmer temperatures, dryer weather, and longer daylight hours may have positively influenced the children's physical activity (Carson and Spence, 2010; Riddoch et al., 2007). Nonetheless, rainfall and temperature were controlled within the multilevel models. Additionally, students may have increased their physical activity as a result of being objectively assessed (Hawthorne Effect; Adair, 1984). The effect could collectively be more apparent in the Control, than Intervention children for whom any increases in physical activity may have been tempered by their high baseline values.

Intervention children engaged in significantly more weekday TPA over time than Control children after receiving the CHANGE! intervention. Further, Intervention children spent longer in MPA, VPA and MVPA than Control children on an average weekday, though such findings were not significant. The lack of change or displacement of Intervention children's weekend TPA is disappointing and suggests that the physical activity promoting messages taught through the CHANGE! curriculum and homework tasks may have promoted weekday physical activity. There are several possible explanations for this, and it is likely that the full explanation involves an element of all of them. The results may reflect that targeting children alone is unlikely to be sufficient in facilitating increases in physical activity outside of school, due to the gatekeeper role of parents and other significant adults in the provision of physical activity (Harrell et al., 1999). This contention is partly supported as the Intervention children engaged in more sedentary time and less MPA outside of school on weekdays. It may also reflect the difficulties in accurately assessing physical activity in this age group and, more specifically, the decreased wear time on weekend days. The number of daily minutes that the children wore the accelerometers was positively associated with physical activity of all intensities and sedentary time. This supports previous research (Masse et al., 2005) and reinforces the need for researchers to account for accelerometer wear time in their analyses so as to avoid bias in physical activity and sedentary time outcomes. Alternatively, it may be that the homework content within the intervention was not employed to the same degree by parents or that the strategies were less extensive, and therefore less effective, than those in the school curriculum. Doak et al. (2006) support this argument advocating that how an intervention addresses a behaviour change is crucial and that the level of active engagement by participants may influence outcomes. It is possible that removal of the structured school environment and school day at weekends is detrimental to some children's physical activity and consequently the intervention effect. However, the negative association of Intervention children and school sedentary time (8.93 less minutes per day) is encouraging given that physical activity levels during the school day tend to be lower than out of school (Gidlow et al., 2008). Questions remain however as to how to effect favourable changes in physical activity out of school through school-based interventions. Greater links with families are most likely required, but the exact nature and contribution of involvement remains unclear (Rowlands et al., 2008).

The CHANGE! intervention was effective in promoting healthy body size through educational activities focused on increased physical activity, healthy eating, and reduced sedentary time. Children in the Intervention schools had significantly lower waist circumferences and BMI SDS, and lower BMI values over time than those from Control schools, when confounding variables were controlled. Recent research has identified waist circumference as a marker with equal prognostic value as BMI, which is associated with various cardiometabolic risk markers in children (Bassali et al., 2010). These findings add further support for the effectiveness of combined school-based physical activity and nutrition interventions. A recent systematic review of school-based obesity prevention interventions reported that significant differences in BMI were evident in 33% of studies that focused solely on physical activity or nutrition, but 45% of studies that combined these approaches were effective (Brown and Summerbell, 2009). Moreover, over half of these studies integrated some or all of the intervention within school curricula, further supporting an appropriate intervention context.

The reductions in waist circumferences and BMI SDS suggest that the integrated curriculum approach used in CHANGE! was effective in maintaining healthy weight and reducing the risk of overweight. The APPLE Project utilised a curriculum intervention component in the form of healthy eating education alongside non-curricular physical activity and also reported significant decreases in intervention children's waist circumferences and BMI SDS (Taylor et al., 2007). The Lekker Fit! study in the Netherlands was similar to CHANGE! in that it focused on active lifestyles and healthy eating through a multi-component intervention that included a classroom lesson and homework element (Jansen et al., 2011). Waist circumference of 9-12 year olds reduced at follow-up by 0.71 cm in the intervention group compared to control (Jansen et al., 2011), which was less than the 1.75 cm difference observed in CHANGE!. A small shift in waist circumference in a population could potentially have a substantial impact upon obesity-related illness and mortality (Robinson, 1999). This finding suggests that CHANGE! may be an effective method of decreasing disease risk associated with excessive adiposity. Significant decreases in waist circumference, BMI and BMI SDS occurred between baseline and post-intervention, though reductions continued at follow-up, though these were not significant. This suggests that the intervention had the greatest effect during curriculum delivery, yet lifestyle changes continued post-intervention. Nonetheless, the follow-up period was shorter than the intervention decreasing the likelihood of a significant reduction taking place.

CHANGE! followed a similar approach to the Planet Health intervention, which reported a significant decrease in girls' but not boys' obesity prevalence at two years follow-up (Gortmaker et al., 1999b). The CHANGE! interaction analysis highlighted how intervention effects for waist circumference and BMI SDS were significantly greater in Intervention group girls. These findings endorse the contention that gender is a significant moderator of school-based energy balance behaviour interventions, which typically appear to work better for girls than boys (Yildirim et al., 2011). There is evidence that girls respond better to school-based interventions (particularly nutrition education; Vandelanotte et al., 2004), and that in relation to physical activity, the consensus that boys are typically more active allows greater scope for increases among girls (Yildirim et al., 2011). The present study supports this contention as the boys engaged in significantly more physical activity (all intensities) than girls, at all three time-points.

In CHANGE! reductions in waist circumference were also evident in normal weight Intervention children, but the interactions were stronger among the overweight/obese children. This contrasts with the significant interaction reported in the APPLE Project, which indicated that BMI SDS decreased among Intervention children classed as normal weight, but not those who were overweight (Taylor et al., 2007). The findings demonstrate that not only was the CHANGE! intervention effective for children across the weight status spectrum, but that it was particularly effective for those who were initially overweight or obese, and who therefore were at greatest potential risks of poor health. By using focusing on the promotion of healthy weight rather than weight loss per se, a favourable response was observed in the overweight/obese group. It is possible that the approach of de-emphasising weight loss but reinforcing healthful behaviours related to energy balance may encourage more sustained changes in behaviour which facilitate positive changes in body size (Vignolo et al., 2008). Moreover, when compared to results of specialist obesity treatment programmes (Sacher et al., 2010), the school-based integrated curriculum approach used in CHANGE! resulted in superior and comparable changes in waist circumference and BMI z-scores, respectively, though cause and effect cannot be inferred. This observation further demonstrates the effectiveness of the CHANGE! intervention approach.

In developed countries prevalence of overweight and obesity is highest in children from low SES families (The NHS Information Centre, 2010; Janssen et al., 2006; Lioret et al., 2007), and there is evidence that low SES children are more likely to spend time in sedentary pursuits than high SES peers (Fairclough et al., 2009; Lioret et al., 2007). To date few studies have assessed interactions between SES and intervention effects on body size or weight status (Brown and Summerbell, 2009). In CHANGE!, Intervention children from low SES families had significantly more pronounced reductions in BMI and BMI SDS than high SES Intervention children. Further, interactions between Intervention group and SES group for TPA suggests that the low SES Intervention group decreased their body size (BMI and BMI SDS) through increases in weekday TPA. However, such conclusions are tentative. Conversely, the KOPS study in Germany reported significantly reduced prevalence of BMI-derived overweight among Intervention children from high SES families, although obesity incidence increased to a non-significant degree (Plachta-Danielzik et al., 2007). Elsewhere though, SES has been shown to be unrelated to changes in anthropometric indices of body size (Sanigorski et al., 2008). Thus, the limited evidence investigating the influence of SES on the effectiveness of school-based interventions to promote healthy weight is equivocal, possibly because studies have employed different measures of SES. In CHANGE! IMD scores (Department for Communities and Local Government, 2008) based on home postal codes were used as an area level indicator of familial SES. Area and individual level measures of SES such as parents' education level, occupations, and incomes, are not perfectly correlated (Roux et al., 2001), and as they are independently associated with youth obesity, they may influence effects of school-based interventions differently (Janssen et al., 2006).

It has been proposed that a dose-response relationship exists between increased sedentary behaviour and unfavourable health outcomes in young people (Tremblay et al., 2011), though this association may be attenuated by physical activity (Steele et al., 2009). Although there was no overall intervention effect on sedentary time, the high sedentary Intervention children accumulated 43 minutes more daily sedentary time than the least sedentary Intervention children. The interactions between Intervention group and sedentary status meant that BMI and BMI SDS were significantly reduced in high but not low sedentary Intervention children relative to the Control group. However, physical activity interactions between Intervention group and sedentary status were not found. Moreover, potential effect modification analyses revealed a significant interaction effect, whereby the high MVPA Intervention children reduced sedentary time by 25.27 minutes during school time. These findings demonstrate that different sociodemographic groups respond to the intervention in different ways. Such results suggest that high sedentary children may have decreased body size through decreases in energy intake (i.e., from the healthy eating component of the intervention), whereas high MVPA children may have decreased their sedentary behaviour during school time. Potential effect modification analyses demonstrated that the CHANGE! intervention significantly reduced waist circumference, BMI, and BMI SDS among Intervention children who were overweight, from the lowest SES families, and who spent most time being sedentary. Children categorised in each of these groups are likely to be at higher risk of poor health outcomes than those who are normal weight, are from high SES families (The Information Centre, 2006), and who spend less time being sedentary (Tremblay et al., 2011). These significant interactions endorse the effectiveness of CHANGE! on children at greatest risk of negative health outcomes.

There are a number of limitations in this pilot study: (i) Missing data were apparent during each analyses model. The major contributor to the 51.9%

reduction in sample size was one school withdrawing from the study and children failing to meet the inclusion criteria for objectively measured physical activity at all three time points. The decreased sample size reduced statistical power, which may explain why the positive changes in weekday physical activity did not reach statistical significance. However, multi-level modelling, in comparison to standard regression models, can include missing data (Twisk, 2006); (ii) The number of schools included in the study was modest which consequently hampers the power of the multi-level analysis approach, despite being the most appropriate analysis method for the clustered design of this study; (iii) There was no on-going record of lesson delivery or evaluation. However, the Intervention school teachers received training in use of the curriculum resource and homework tasks. Although teachers provided feedback at the end of the study, any inconsistencies in lesson delivery that occurred during the 20 week intervention period could not be addressed at the time, which increased the risk of intervention infidelity. This said, Summerbell and colleagues (2012) advocated that teachers involved in school-based interventions must be allowed to adapt lessons specifically to their classes. A thorough process evaluation including weekly teacher lesson evaluations and observations would have addressed this issue, but human resource constraints meant that this was not feasible; (iv) The lack of a long-term follow-up, due to schools breaking up for summer holidays, means the sustainability of behavioural changes cannot be fully assessed. To impact health, behaviour change needs to be sustained in the medium (i.e., 6 months) and long-term (i.e., 12 months or more ; National Obesity Observatory, 2009). A large, suitably powered (at the school level) trial, with a longer follow-up period, is required to more comprehensively assess the effect of CHANGE!.

Strengths of the CHANGE! intervention lie in the delivery of the intervention by school teachers, how it links with various aspects of the National Curriculum, and its flexible design (i.e., allowing teachers to decide how and when they would use the intervention resources), which respected the autonomy of teachers. These features improve the potential for future sustainability of the intervention and deliver consistent messages across a range of subjects taught in the curriculum (Gortmaker et al., 1999a; Gortmaker et al., 1999b; Warren et al., 2003). Furthermore, the current interventions physical activity component was a cost-effective education-based intervention teaching the children about the benefits of physical activity and encouraging them to make healthy choices, whereas previous educative research has also included opportunities to be active (Gorely et al., 2009b), which are less sustainable long-term. Over 75% of the study population consented to participate which reduced the risk of sampling bias, and randomisation occurred at the school level which reduced the risk of contamination to Control group children. The intervention content was relevant to the local context of the schools and was informed by the opinions and beliefs of the participants (Chapter 3; Mackintosh et al., 2011). Summerbell et al. (2012) suggested that teachers should be encouraged to include country- and cultural-specific activities. Moreover, thorough intervention development and explanation advances previous research; most intervention programmes have not reported on their rationale, development, exact content, or method of implementation which hampers understanding about what aspects of interventions work and why (Lloyd et al., 2011). An important strength of the current research is the use of objective measures of physical activity which provide a rigorous and sensitive test of the intervention effects and removes the bias associated with self-report. The multilevel analyses allowed school and child-level covariates to be included which meant potential confounders were accounted for. Further strengths of the study were the use of sample-specific cut-points and the analysis of MPA and VPA, as well as MVPA.

5.5: Conclusions

The CHANGE! school-based curriculum intervention led to significant increases in VPA and weekday TPA over time among the Intervention children compared to the Control group. Moreover, the intervention was effective in reducing waist circumference and BMI SDS over time after adjustment for covariates. The intervention was most effective among Intervention group children who were female, overweight/obese, from lower SES families, and who engaged in the highest levels of sedentary behaviours. In this sense the CHANGE! intervention was effective among youth known to be at greatest risk of poor health.

Thesis Study Map

Study	Objectives and Key Findings
Study 1: Using formative research to develop CHANGE!: A curriculum-based physical activity promoting intervention	**Objectives:** • Elicit the views of primary school children aged 9-10 years old, their parents, and teachers in relation to their own knowledge, behaviours and perceptions towards childhood physical activity. • To examine perceived benefits and barriers to physical activity participation. • Use these data to subsequently inform the design of a tailored physical activity intervention programme, CHANGE! (Children's Health, Activity, and Nutrition: Get Educated!). **Key Findings:** • Consistent themes between SES and gender for knowledge, behaviours, and perceptions towards physical activity. • Families have a powerful and important role in promoting health-enhancing behaviours. Involvement of parents and the whole family is a strategy that could be significant to increase children's physical activity levels.
Study 2: A calibration protocol for population-specific accelerometer cut-points in children	**Objectives:** • To test a field-based protocol to generate behaviourally valid, population-specific accelerometer cut-points for sedentary behaviour, moderate, and vigorous physical activity. • Use these cut-points to subsequently analyse physical activity data for CHANGE!. **Key Findings:** • Cut-points of ≤372, >2160 and >4806 counts•min^{-1} representing sedentary, moderate and vigorous intensity thresholds, respectively, provided the optimal balance between the related needs for sensitivity and specificity. • Evenson et al. (2008) sedentary cut-points of 100 counts•min^{-1} should be used. • The development of an inexpensive and replicable field-based protocol to generate

	behaviourally valid and population-specific cut-points may improve the classification of physical activity levels in children, which could enhance subsequent intervention evaluation.
Study 3: Promoting healthy body size in Primary school children through physical activity education: The CHANGE! intervention	**Objective:** • To assess the effect of the CHANGE! school-based physical activity intervention on habitual physical activity and body size in 10-11 year old children. **Key Findings:** • The CHANGE! school-based curriculum intervention was effective in reducing waist circumference and BMI SDS over time after adjustment for covariates. • The intervention also led to significant increases in VPA and weekday TPA over time among the intervention children compared to the Control group. • The intervention was most effective among Intervention group children who were female, overweight/obese, from lower SES families, and who engaged in the highest levels of sedentary behaviours. These are children known to be at the greatest risk of poor health.

Chapter 6

Synthesis

Chapter 6: Synthesis

The development and maintenance of healthy physical activity behaviours during childhood are of utmost importance for physiological and psychological health and well-being (NICE, 2009). Children's health can be adversely affected by insufficient levels of physical activity (Dencker and Andersen, 2008b; Janssen and Leblanc, 2010; Jimenez-Pavon et al., 2010; LaMonte and Blair, 2006; Reichert et al., 2009; Riddoch et al., 2007) and high levels of sedentary behaviour (Tremblay et al., 2010). Current physical activity guidelines encourage children to engage in 60 minutes or more of moderate-to-vigorous physical activity (MVPA) each day (Department of Health, 2011). However, research indicates that many children fail to meet recent recommendations (Hills et al., 2011) and engage in large amounts of sedentary behaviour (Steele et al., 2010).

The school setting provides an ideal environment for population-based physical activity interventions and has the potential to play a critical role in the prevention of overweight and obesity (Lloyd et al., 2011). Specifically, curriculum-based strategies ensure that 100% of students are exposed to interventions, thereby increasing reach and reducing stigmatisation of children who are inactive, unfit, or obese (Dobbins et al., 2009), and of low socio-economic backgrounds (Fox et al., 2004). To this end, curriculum-based interventions can simultaneously target children both at risk, and not at risk, of future chronic diseases, as well as increasing knowledge and behaviour conducive to healthy lifestyles. The intent of curriculum-based interventions to promote physical activity is to increase the overall percentage of children meeting recommended guidelines and to increase the duration of MVPA engaged in on a daily basis. In order to achieve such an outcome, interventions need to target physical activity levels of children both in school and at home, therefore some form of parental or family involvement is required to help form life-long healthy behaviours (Pearson et al., 2009). Healthy lifestyle curriculums can be easily utilised within the school day and could effectively address physical activity at home (Siegrist et al., 2011). Characteristics of successful primary school-based interventions seem to vary in effectiveness according to gender, age, or weight status of the children (Brown and Summerbell, 2009). However, there is equivocal evidence that such interventions can be successful in UK primary schools.

The primary aim of this thesis was to increase 10-11 year old children's MVPA through a combined physical activity and healthy eating curriculum-based intervention entitled CHANGE! (The Children's Health, Activity and Nutrition: Get Educated!). As physical activity is a complex behaviour, the National Institute for Clinical Excellence (NICE, 2009) recommend that for interventions targeting physical activity promotion to be successful and sustainable, they should be grounded with a psychological theory and model. CHANGE! was developed and implemented based upon Green et al.'s (1980) Precede-Proceed model and Welk's (1999) Youth Physical Activity Promotion Model (YPAPM).

The early work presented in this thesis investigated the subjective views of children, their parents, and teachers to examine knowledge, beliefs and barriers to physical activity, to increase primary school children's MVPA (Study 3). The premise for the use of a qualitative informative study was twofold: (i) a comprehensive understanding of the perceived benefits and barriers to physical activity, afforded by qualitative research, is deemed imperative in the design of successful interventions (NICE, 2007), and (ii) the need to consult and engage intervention participants (e.g., children, parents, and teachers) within the context of their community has been advocated for some time (Potvin et al., 2003). The results of the pen profiles utilised in **Study 1** indicated that despite high levels of child and parent knowledge about the importance of physical activity engagement, this knowledge did not appear to always translate into actual physical activity behaviours. This was a key element which was addressed within the lesson and homework plans of the intervention. Moreover, these results suggest that incorporating a family-based component is imperative in the design and implementation of CHANGE! (Study 3).

Study 2 developed and evaluated a field-based calibration protocol to create child behaviourally valid and population-specific accelerometer cut-point thresholds. Age and location specific children performed a broad range of structured and unstructured activities, in order to generate sample-specific cut-points for Study 3. Results demonstrated that cut-points of ≤372, >2160 and >4806 counts•min^{-1}, for sedentary time, moderate physical activity (MPA) and vigorous physical activity (VPA), respectively, were most appropriate for the given sample. The generated cut-points were considered to provide excellent discrimination across physical activity intensities (AUC = 0.976 – 0.995). The results also demonstrated high AUC, sensitivity and specificity, for all three cut-points in comparison to other studies adopting the ROC approach (Alhassan and Robinson, 2010; Evenson et al., 2008; Sirard et al., 2005; Van Cauwenberghe et al., 2010). However, the sedentary cut-point of 372 counts•min^{-1} could be perceived as being relatively high and could therefore encompass light physical activity as well as sedentary time (Trost et al., 2011). Upon reflection, the protocol used in Study 2 did not incorporate any specific light activities, nor did the direct observation system allow for such activities to be coded. Future research should develop methods in order to address the aforementioned protocol issue and subsequently generate population-specific sedentary cut-points. Nonetheless, these results enabled the MPA and VPA sample-specific cut-points to be used with confidence in Study 3. Moreover, the VPA cut-point may have been more proficient to previously utilised cut-points and allowed a detection of a shift in physical activity intensity, and specifically the significant VPA intervention effect in Study 3.

Study 3 assessed the effect of the CHANGE! school-based physical activity and healthy eating intervention on habitual physical activity, in the primary instance, and body size, in 10-11 year old children. The CHANGE! intervention was effective in increasing VPA, weekday total physical activity (TPA), and decreasing body size (waist circumference and BMI SDS). Moreover, results revealed that even though not significant, lower BMI values and higher weekday MPA, VPA and MVPA were observed among the Intervention children. These results suggest that the intervention was most effective on weekdays. Perhaps the physical activity promotion messages taught through the CHANGE! curriculum and homework tasks promoted weekday physical activity, or the homework content may not have been employed to the same degree by parents, adding support to previous research (Doak et al., 2006). However, it was difficult to know whether the dose-response messages were consistent across Intervention schools, and also how strong the homework message was. In line with Phase 7 of the Precede-Proceed model (Green et al., 1980), this should be considered in future studies for process evaluation, Nevertheless, the findings demonstrate that the CHANGE! intervention was most effective amongst those sociodemographic groups at greatest risk of poor health status.

While the scope of the present thesis was to increase children's physical activity levels, of at least moderate intensity, via a curriculum-based primary school intervention, it is important to recognise that the scope of the results goes beyond the primary school setting. As outlined by the YPAPM (Welk, 1999) parents and significant others, as well as communities, also play important roles in changing physical activity behaviour. A common finding from studies 1 and 3 is that parents play a vital role in physical activity promotion in children outside of the school environment. This consensus concurs with Welk (1999) who advocated that in order for healthy physical activities to be adopted, and, more importantly, maintained, it is important that they are enabled and reinforced by people outside of the school environment. However, such conclusions based on the findings of Study 3 are tentative. The power of weekend data, for example, was reduced due to the lack of compliance to the accelerometer protocol. It is envisaged that the decreased compliance on weekend days, and indeed after school, was due to lack of parent support regarding the research study, or lack of the structured school day, or perhaps a combination of them both. This appears to be a generic problem, despite the lack of research reporting accelerometer compliance. Future research should therefore explore the issues of compliance to accelerometer protocols in children, as well as the role of parents in reinforcing wear time.

Given that the CHANGE! intervention had a strong behavioural focus, and sociocultural factors and policy are of critical importance to behavioural change, the Precede-Proceed model (Green et al., 1980) was adopted as a guiding framework. CHANGE! therefore followed the stepwise approach guided by the Precede-Proceed model (Green et al., 1980), which has recently been applied for the development of a large scale European intervention study (Manios et al., 2012). The information and knowledge obtained in Study 1 during the PRECEDE phases guided the development of the intervention, to insure the programme was not an intuitive process, rather the result of a systematic and dynamic procedure addressing the needs of the target population in the most effective way, providing a tailor-made and therefore a potentially more cost-effective approach. Using the Precede-Proceed strategic planning model, formative research (Study 1), and partnership with a local Council, the programme designed curriculum materials and implemented 20 healthy lifestyle sessions, which significantly increased VPA, total weekday physical activity, and decreased body size (waist circumference and BMI SDS). Results from these studies support the potential for using formative research to develop and implement a health-enhancing curriculum-based intervention. Results further suggest that the use of a simple, field-based protocol is sufficient to generate population-specific accelerometer cut-points to subsequently apply to such an intervention sample. In addition, in line with reinforcing and enabling elements of the Precede-Proceed model (Green et al., 1980) and the YPAPM (Welk, 1999), out of school physical activity is more difficult to change because of the gatekeeper role of parents and others in the provision of physical activity and thus targeting children alone is likely to be insufficient to facilitate change. On the basis of these findings it is plausible to suggest that there is need for interventions to further target the family aspect of curriculum-based interventions.

Chapter 7

Conclusions

Chapter 7: Conclusions

The overall aim of the thesis was to develop, implement and assess the effect of the Children's Health, Activity and Nutrition: Get Educated! (CHANGE!) project, which targets physical activity and healthy eating through a school-based curriculum intervention delivered by in-service teachers.

Study 1

Study 1 achieved its objectives, successfully eliciting subjective views of children, their parents, and teachers about perceived benefits and barriers to physical activity participation. Strong emergent themes, such as fun, enjoyment and social support being important predictors of physical activity participation were established. Moreover, several barriers to participation such as lack of parental support were identified across all group interviews. The final objective of this study was to subsequently inform the design of CHANGE!. Families have a powerful and important role in promoting health-enhancing behaviours and therefore involvement of parents and the whole family is imperative in intervention design.

Study 2

Study 2 successfully generated population-specific cut-points to inform the analysis of the CHANGE! intervention. Cut-points of ≤372, >2160 and >4806 counts•min^{-1} representing sedentary, MPA and VPA intensity thresholds, respectively, provided the optimal balance between the related needs for sensitivity and specificity. This novel study demonstrated the potential utility of an ecologically sound, simple, inexpensive field-based protocol to derive optimal population-specific physical activity thresholds. The field-based protocol may help standardise accelerometry calibration approaches, reduce confusion generated through the plethora of reported cut-points and competing devices, and accommodate population-specific findings. The MPA and VPA thresholds generated were robust for the population-specific sample.

Study 3

The main objective of this study was to assess the effect of the CHANGE! school-based physical activity intervention on habitual physical activity and body size in 10-11 year old children. CHANGE! was effective in increasing VPA, weekday total physical activity, and reducing waist circumference and BMI SDS. The intervention was most effective among Intervention group children who were female, overweight/obese, from lower SES families, and who engaged in the highest levels of sedentary behaviours, and therefore those children known to be at greatest risk of poor health. Further work is required to test the sustained effectiveness of this approach in the medium and long-term.

Chapter 8

Recommendations

Chapter 8: Recommendations

There are a number of recommendations from this thesis to further the line of research in physical activity and health promotion in children. Despite the need for more research, some recommendations for practice can be encouraged at this time.

8.1: Recommendations for practice

- Teachers should promote physical activity and healthy behaviours through the curriculum.
- Parental involvement could be an integral part of school-based interventions as targeting children alone is likely to be insufficient to facilitate change. Teachers and schools should therefore encourage family involvement in promoting physical activity as much as possible, perhaps through the use of homework tasks or family fun days.
- Schools should maximise available playground and field areas in order to promote physical activity during break and lunch times. This may require some changes within the school environment and encouragement of school staff.
- Teachers and school staff should be encouraged to act as role models by demonstrating more physical activity during the course of the school day.
- Wigan Council should integrate the CHANGE! curriculum borough wide in order to more comprehensively assess the effect on physical activity.

8.2: Recommendations for future research

- Researchers should utilise comprehensive formative research to incorporate the opinions and beliefs of the participants and ensure intervention content is relevant to the local context of the school.
- Future research should employ the use of pen profiles, which are considered appropriate for representing analysis outcomes from large datasets via a diagram of composite key emergent themes, and are accessible to researchers who have an affinity for both quantitative and qualitative backgrounds.
- There is need for further holistic school-based interventions with a longer follow-up period in order to fully assess the long-term sustainability of behavioural changes.
- Larger, suitably powered (at the school level) trials, are required to more comprehensively assess the effect of combined physical activity and healthy eating curriculum-based interventions.
- Since school-based physical activity interventions can be linked to the curriculum and are associated with some positive effects, such activities should continue and be encouraged by local public health authorities. Future interventions should combine an environmental aspect to enhance the physical activity affect.
- Future work is needed to develop a protocol to generate population-specific sedentary cut-points.
- Future work is needed to ascertain how to get children more physically active on weekend days.
- Research should consider the effect dog ownership has on children's physical activity levels and the associated intensity.

- Future research should explore the issues of compliance to accelerometer protocols in children, as well as the role of parents in reinforcing wear time.
- There is need for interventions to further target the family aspect of curriculum-based interventions.
- To build upon the population-specific cut-point protocol presented in Study 2, future research should consider relative cut-points based on participant descriptives, such as body mass.
- All future intervention studies should report moderate physical activity (MPA) and vigorous (VPA) separately and utilise comprehensive analytical techniques controlling for relevant confounders.

Chapter 9

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Appendices

Appendix 1:

Ethical Approval

LIVERPOOL JOHN MOORES UNIVERSITY

PROJECT INFORMATION SHEET

Title of Project: CHANGE! (Children's Health, Activity and Nutrition: Get Educated!)

Name of Researchers and School/Faculty: *Dr. Stuart Fairclough, Dr. Lynne Boddy, Dr. Ian Davies, Dr. Allan Hackett, Rebecca Gobbi, Genevieve Warburton, Kelly Mackintosh (The Faculty of Education, Community and Leisure, Liverpool John Moores University).*

We are inviting Year 6 children to take part in this project.

In Wigan there are lots of programmes and opportunities for children to take part in physical activity and sport, and to encourage healthy eating. Being active and eating well is important because it is good for our health. The purpose of this project is to improve the eating habits and physical activity levels of Year 6 pupils in Wigan. The project will also try and find out what children think about their own physical activity and eating habits. The information collected will help us to learn how well the sport and physical activity programmes and the healthy eating messages in Wigan are followed.

Your school will either be assigned to a control group or an intervention group. All schools will be invited to take part in a number of sophisticated measurements prior to the start of the intervention phase (September-November 2010) and after completion of the intervention phase (April-May 2011). All children will be invited to take part in the field based measures, and a representative sample of children will also be invited to take part in more advanced lab based measurements.

If you are selected as an intervention school we will provide you with 20 lesson plans and supplementary information. If you are selected as a control school you will be provided with the lesson plans and information at the end of the project. These lesson plans are designed to be delivered on a weekly basis for around an hour per lesson. It is important that we have control schools in order to assess the beneficiary health effects of the lessons and the uptake of the messages we have designed.

Parents/guardians will be asked to provide consent to take part in all measurements which we will invite their child to take part in, and we will provide information sheets for the parent and the child to read and sign.

Testing Session A (in school)

All children

If the child takes part they will be asked to complete questionnaires, asking about the types of physical activities they do, what they think about their own physical activity, how often they take part in physical activity, and about aspects of their eating habits. A researcher will explain how to fill in each questionnaire and will be there while the children complete them, in case they need to ask about anything they are not sure of.

We will measure each child's weight, height, waist circumference, hip circumference, body composition, sitting height and blood pressure. All of these measures will take place away from the rest of the group, and no one but the researchers will see the results. Weight will be measured by asking the child to stand on some weighing scales with their shoes removed. Height and sitting height will be measured using a height meter; each child will be asked to stand and then sit with their back to the height meter and the researcher will record the standing and sitting height values. A non-elastic measuring tape will be used to measure the distance around the child's waist and hips. We will use a different type of scales to measure body composition, where the child stands on the scales bare-footed and the scales give us a measure of muscle tissue, total body water and %body fat. We will also run a fitness session. Children will complete a fitness assessment using a shuttle runs test, often known as the bleep test.

Completing the questionnaires, and having the measurements taken should take no longer than three hours. All of these measures will take place during school time on school grounds, for the measurements we will require a measurement area this can either be a section of the sports hall, or an empty classroom or any other convenient room within school. Questionnaires can be completed in the classroom. We will require use of the playground or sports hall for the fitness test.

To measure the child's physical activity we will ask them to wear an activity monitor attached to an elastic belt around their waist. These monitors measure and record how much activity a person does and are similar to pedometers. We would like the children to wear them for 7 days. We ask children to put on the monitor when they get up in the morning, and take it off when they go to bed. The only other times we would ask the children to remove the activity monitors would be during any activities where they might get wet, like swimming, showering, taking a bath, etc. After 7 days the researchers will be at school to collect the monitors back from the children.

We will also be looking at the types of foods the families like to eat and see how much the children know about foods. To do this we will ask the children to fill in a couple of short questionnaires in school and there will also be a few things that we would like the children to do at home such as making a simple report of a mealtime on a form we will give them, making a list of the foods stored in your home and collecting a till receipt from the supermarket (with the financial information taken off).

Some Children

A selection of children will also be asked to take part in the following additional measurements which will be carried out on two different days. One will be done at school and should take less than an hour, and the other will be at Liverpool John Moores University and again should take a school day.

Testing Session B:
Markers of cardiovascular risk

For this the selected children should not have eaten breakfast, and only consumed water on the morning of blood sampling. For this we require a room or a section of the school hall where we will set up a blood sampling area and a quiet area for them to relax in before and after sampling.

During this test a fully trained and experienced researcher will take a very small blood sample from the child's fingertip. This blood sample will be analysed to look for levels of cholesterol and fats in the blood, and see if any markers of inflammation are present.

This information provides very useful information on the health of children, but we are not screening for any current health problems. After the blood sampling we will provide breakfast for the children, or if your school offers a breakfast club we will pay for the child to have breakfast from breakfast club, the children will be looked after by researchers to make sure they are OK. They will then return to lessons and carry on with the school day as normal after they have had their breakfast.

Testing Session C (At Liverpool John Moores University)

We will arrange for children to be transported to the university from school at the start of the school day and return them by the end of the school day. Children will be required to bring their own packed lunch with them to the lab day.

DEXA whole body scan

This machine scans the whole body, providing a picture of the skeleton and measuring bone, fat and muscle tissue. The scan takes four minutes, and uses radiation that is the equivalent of a two-hour flight on an aeroplane. Children will receive a picture of their skeleton in their results pack.

Ultrasound

During this test a researcher will scan the heart to measure its dimensions, and will also measure the thickness of some major arteries. This technique follows the same principle of scans used to produce images of a baby in the womb. We will also use another ultrasound technique to see how the child's arteries in the arms are functioning. To complete this test a blood pressure cuff will be inflated around the child's arm and then deflated, we then look at how the child's blood vessels react. Blood pressure will also be measured at this time. Researchers will fully explain the tests to children and answer any questions they may have.

Anthropometry

Simple height, weight, waist circumference, hip circumference and skinfolds measures will be taken.

Aerobic fitness

This will involve a treadmill based running test to maximum, and should last between 9 and 15 minutes. The participant will wear a face mask and a heart rate monitor. We will ensure that your child is fully warmed up before the test and familiarised with the treadmill. Children will also wear a harness to prevent any fall risk whilst on the treadmill. We will also ensure your child completes a cool down, and monitor your child's heart rate throughout.

After School

When we return to school we will run an after school skills assessment. In this session, children will be assessed performing skills such as the hop, vertical jump, sprint, kick, catch and throw. They will be filmed performing these skills to allow for slow motion analysis. These video's will be kept in a secure setting and will only be handled by approved persons. For this we require use of the school playground and it should take no longer than 1 hour.

For more information or if you have any questions about CHANGE! please don't hesitate to contact one of the researchers:

Address: Liverpool John Moores University, IM Marsh, Barkhill Rd, Liverpool, L17 6BD

Telephone: **0151 231 5271**

Wigan
Council

CHILDREN'S HEALTH, ACTIVITY AND NUTRITION: GET EDUCATED!

LIVERPOOL JOHN MOORES UNIVERSITY

PARENT/GUARDIAN/CARER

INFORMATION SHEET

Title of Project: CHANGE! (Children's Health, Activity and Nutrition: Get Educated!)

Name of Researchers and School/Faculty: *Dr. Stuart Fairclough, Dr. Lynne Boddy, Dr. Ian Davies, Dr. Allan Hackett, Rebecca Gobbi, Genevieve Warburton, Kelly Mackintosh (The Faculty of Education, Community and Leisure, Liverpool John Moores University).*

Your child is being invited to take part in a research project. Before you decide it is important that you understand why the research is being done and what it involves. Please take time to read the following information. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you want your child to take part

1. What is the purpose of the study?

In Wigan there are lots of programmes and opportunities for children to take part in physical activity and sport, and to encourage healthy eating. Being active and eating well is important because it is good for our health. The purpose of this project is to improve the eating habits and physical activity levels of Year 6 pupils in Wigan. The project will also try and find out what children think about their own physical activity and eating habits. The information collected will help us to learn how well the sport and physical activity programmes and the healthy eating messages in Wigan are followed.

2. Does my child have to take part?

No. It is up to you and your child to decide whether or not you want to them to take part. If you do you will be given this information sheet and asked to sign a consent form. **Your child is still free to withdraw from the project at any time and without giving a reason. Withdrawing will not affect your child's educational or sporting opportunities in any way.**

3. What will happen to my child if they take part?

If you decide to allow your child to take part they will be asked to complete questionnaires, asking about the types of physical activities they do, what they think about their own physical activity, how often they take part in physical activity, and about aspects of their eating habits. A researcher will explain how to fill in each questionnaire and will be there while the children complete them, in case they need to ask about anything they are not sure of.

We will measure each child's weight, height, waist circumference, hip circumference, body composition, sitting height and blood pressure. All of these measures will take place away from the rest of the group, and no one but the researchers will see the results. Weight will be measured by asking the child to stand on some weighing scales with their shoes removed. Height and sitting height will be measured using a height meter; each child will be asked to stand and then sit with their back to the height meter and the researcher will record the standing and sitting height values. A non-elastic measuring tape will be used to measure the distance around your child's waist and hips. We will use a different type of scales to measure body composition, your child stands on the scales bare-footed and the scales give us a measure of muscle tissue, total body water and % body fat. After these measurements children will complete a fitness assessment using a shuttle runs test, also known as the bleep test.

Completing the questionnaires, and having the measurements taken should take no longer than two hours. All of these measures will take place during school time on school grounds.

To measure your child's physical activity we will ask them to wear an activity monitor attached to an elastic belt around their waist. These monitors measure and record how much activity a person does and are similar to pedometers. We would like the children to wear them for 7 days. We ask children to put on the monitor when they get up in the morning, and take it off when they go to bed. The only other times we would ask the children to remove the activity monitors would be during any activities where they might get wet, like swimming, showering, taking a bath, etc. After 7 days the researchers will be at school to collect the monitors back from the children. If you and your child agree to give us a contact mobile phone number we will send a maximum of one text message per day during the physical activity monitoring to remind children to wear the monitor and bring it back to school after seven days.

We will also be looking at the types of foods your family like to eat and see how much your child knows about foods. To do this we will ask your child to fill in a couple of short questionnaires in school.

4. Are there any risks / benefits involved?
Your child may feel apprehensive when researchers are taking measures such as height and weight. We will only share the results with your child and they can ask questions at any time. Your child may become out of breath and flushed during the fitness test, this is similar to what your child experiences when playing in the playground or taking part in sport. Your child will be monitored throughout, and they can stop at any point.

You and your child may find the information gained relating to health, physical activity levels and participation, and information relating to eating habits, interesting and informative.

5. Will my child's participation in the study be kept private?
All of the results of the research will only be viewed by the researchers. We will produce reports of the findings, but this will only give general information about the Year group as a whole. At no stage will your child's name be used when we report any of the results and we will treat all data in the strictest confidence.

If you would like your child to take part in this research please complete and return the consent form.

For more information or if you have any questions about CHANGE! please don't hesitate to contact one of the researchers:

Address: Liverpool John Moores University, IM Marsh, Barkhill Rd, Liverpool, L17 6BD.

Telephone: 0151 231 5271

LIVERPOOL JOHN MOORES UNIVERSITY

PARENT/GUARDIAN/CARER CONSENT FORM

Project Name: CHANGE!

Researchers: *Dr. Stuart Fairclough, Dr. Lynne Boddy, Dr. Ian Davies, Dr. Allan Hackett, Rebecca Gobbi, Genevieve Warburton, Kelly Mackintosh.*

The Faculty of Education, Community and Leisure, Liverpool John Moores University

1. I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and if I have asked questions these have been answered satisfactorily. [1]

2. I understand that my child's participation is voluntary and that my child is free to withdraw at any time, without giving a reason and that this will not affect mine or my child's legal rights. [2]

3. I understand that any personal information collected during the study will be anonymised and remain confidential. [3]

4. I give permission for photographs/video to be taken of my child during the project, which may be used for subsequent academic/promotional purposes associated with LJMU, Wigan Council and Ashton, Leigh and Wigan PCT. [4]

5. I agree my child can take part in the above study. [5]

Name of Participant ______________________________

Parent/Guardian/Carer Signature ______________________________

Date ________________________

LIVERPOOL JOHN MOORES UNIVERSITY

CHILD PARTICIPANT INFORMATION SHEET

Project Name: *CHANGE!*

Title of Project: CHANGE! (Children's Health, Activity and Nutrition: Get Educated!)

Name of Researchers and School/Faculty: *Dr. Stuart Fairclough, Dr. Lynne Boddy, Dr. Ian Davies, Dr. Allan Hackett, Rebecca Gobbi, Genevieve Warburton, Kelly Mackintosh (The Faculty of Education, Community and Leisure, Liverpool John Moores University).*

You are being invited to take part in a research project. Before you decide it is important that you understand why the research is being done and what it involves. Please take time to read the following information. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you want to take part.

6. What is the purpose of the study?

In Wigan there are lots of opportunities for children to take part in physical activity and sport, and activities that encourage healthy eating. Being active and eating well is important because it is good for our health.

The purpose of this project is to improve eating habits and physical activity of Year 6 pupils and their families in Wigan. The project will also try and find out what children think about their own physical activity and eating habits. The information collected will help us to learn how well the sport, physical activity and healthy eating programmes in Wigan are working.

7. **Do I have to take part?**
No. It is up to you to decide whether or not to take part. If you do you will be asked to sign the assent form. You are still free to drop out at any time and without giving a reason, and we will stop taking any measures or asking you to fill out any questionnaires as soon as you tell us you want to stop. Dropping out will not affect your school or sporting opportunities in any way.

8. **What will happen to me if I take part?**
If you decide to take part you will be asked to fill in questionnaires, asking about the types of physical activities you do, what you think about your own physical activity, how often you take part in physical activity, and aspects of your eating habits. A researcher will explain how to fill in each questionnaire and will be there whilst you complete them, in case you need to ask about anything you are not sure of.

- We will measure everyone's weight, height, sitting height, blood pressure, the distance around your waist and hips and look at how much muscle and fat you have in your body. All of these measures will take place away from the rest of the group, and no one but the researchers will see the results.

- Weight will be measured by asking you to stand on some weighing scales with your shoes taken off.

- Height and sitting height will be measured using a height meter; you will be asked to stand and then sit with your back to the height meter and the researcher will record your standing and sitting height.

- Blood pressure will be measured by placing a cuff around your arm which will squeeze your arm for a few seconds before releasing again.

- The distance around your waist and hips will be measured using a measuring tape.

- We will look at how much muscle, fat and water is in your body using a special type of scales. You will stand on the scales with your bare feet and it will give us a reading. We won't show any of your results to anyone else.

- We will also do a fitness session, where we will ask you to complete a shuttle run test.

- Completing the questionnaires and having the measurements taken should take no longer than two hours. All of these measures will take place at school in school time. Your class teacher will be there along with the researchers who will do the measurements with you.

- To measure your physical activity we will ask you to wear an activity monitor attached to an elastic belt around your waist. These monitors measure and record how much activity you do and are a bit like pedometers.

- We would like you to wear them for 7 days. You put them on when you get up on a morning and take them off when you go to bed. You also need to take the monitor off when doing any activities where they might get wet, like swimming, showering, taking a bath, etc. After 7 days the researchers will be at school to collect the monitors back from you. If you are happy for us to do so, we will send either your parent/guardian or yourself a message each day of the physical activity monitoring to remind you to wear it and to bring it back to school after seven days.

- We will also be looking at the types of foods you and your family like to eat and see how much you know about foods. To do this we will ask you to fill in a couple of short questionnaires in school.

9. Will my taking part in the study be kept private?

All of the results of the research will only be viewed by the researchers. We will write reports about the project, but this will only give general information about your year group as a whole. At no time will your name be used when we write any of the results.

For more information or if you have any questions please contact one of the researchers:

Address: Liverpool John Moores University, IM Marsh, Barkhill Rd, Liverpool, L17 6BD

Phone: **0151 231 5271**

LIVERPOOL JOHN MOORES UNIVERSITY

ASSENT FORM FOR CHILDREN

Project Name: CHANGE!

Researchers: *Dr. Stuart Fairclough, Dr. Lynne Boddy, Dr. Ian Davies, Dr. Allan Hackett, Rebecca Gobbi, Genevieve Warburton, Kelly Mackintosh.*

The Faculty of Education, Community and Leisure, Liverpool John Moores University

To be completed by the child participant: Please circle your answer to the questions below.

Have you read (or had read to you) information about this project?	Yes/No
Do you understand what this project is about?	Yes/No
Have you asked all the questions you want?	Yes/No
Have you had your questions answered in a way you understand?	Yes/No
Do you understand it's OK to stop taking part at any time?	Yes/No
Are you happy to take part?	Yes/No

If you **don't** want to take part, don't sign your name!

If you do want to take part, please write your name below

Your name ______________________________

Date ______________________________

CHANGE! (Children's Health, Activity and Nutrition: Get Educated!) 10/ECL/039

Liverpool John Moores University Research Ethics Committee (REC) has reviewed the above notification of major amendments by Chair's action. I am happy to inform you that the Committee are content to give a favourable ethical opinion and recruitment to the study can now commence.

Approval is given on the understanding that:

- any adverse reactions/events which take place during the course of the project will be reported to the Committee immediately;
- any unforeseen ethical issues arising during the course of the project will be reported to the Committee immediately;
- any substantive amendments to the protocol will be reported to the Committee immediately
- the LJMU logo is used for all documentation relating to participant recruitment and participation eg poster, information sheets, consent forms, questionnaires. The LJMU logo can be accessed at www.ljmu.ac.uk/images/ljmulogo

For details on how to report adverse events or amendments please refer to the information provided at http://www.ljmu.ac.uk/RGSO/RGSO_Docs/EC8Adverse.pdf

Please note that ethical approval is given for a period of five years from the date that the original approval was granted and therefore the expiry date for this project will be June 2010. An application for extension of approval must be submitted if the project continues after this date.

Yours sincerely

PP:

Appendix 2:

ActiGraph Instructions

Wigan Council

CHANGE!

CHILDREN'S HEALTH, ACTIVITY AND NUTRITION: GET EDUCATED!

liverpool JMU

Parent/Guardian Information:

Tips for Children Wearing the ActiGraph Activity Monitor

The ActiGraph activity monitor is a small, light and unobtrusive piece of equipment that is attached to an elastic belt and worn on the right hip. It records movements such as walking, running, jumping, stepping, etc. and stores them in its memory as 'movement counts'. This information can then be downloaded to computer and used to assess physical activity levels.

Putting the ActiGraph on

The ActiGraphs will be numbered and each child will be assigned a number at the start of the programme. They will wear the same numbered ActiGraph for each day of monitoring. The monitor should be positioned on or just above the right hip and the belt buckle 'snapped' into position. Please try and make sure the children wear the monitors from waking to bedtime each day.

How tight should the belt be?

The monitor should sit securely in position, without being so tight that it is uncomfortable, and without being so loose that it is flapping about when the children are running and jumping.

Does the monitor have to be worn on the outside of the child's clothes?

The ActiGraph can be worn outside the child's clothes, or underneath their clothes. In particular this may be more comfortable for girls wearing dresses. The aim is for the children to go about their normal activities, and to basically 'forget' that they are wearing the monitor. Therefore, the monitor should be worn wherever it feels most comfortable for the child.

Do I have to do anything to switch the monitor on?

No, the monitors will be set-up before being handed out. Although some of the monitors may contain a deep-sunken button, it is quite inconspicuous and pretty difficult to press in. There is no need for the button to be pressed while the monitors are being worn.

What happens if a red light starts to flash?

You may see a small red light blinking on and off on some of the monitors. This is just a signal to indicate that the batteries may require charging within the next few days. The battery life is 14 days so it is unlikely that the monitors will lose power, even if the light starts to blink. If a light does begin to blink this is not a problem as the monitor will be recharged before it is next used.

Are there any activities that the ActiGraph cannot be worn for?

The monitor should not be worn for swimming, bathing, showering, or any other activities where is may get soaked with water. Also, if your child is involved in full contact sports like rugby, wrestling, etc. then the monitor could get damaged, as well as cause injury. If the child is taking part in any of these types of activities, please remove the monitor and replace it after the activity has finished.

Do I need to do anything else?

We would ask that you keep a log of the times when the activity monitor is removed (e.g., for swimming). Your child will have been given an activity log to take home, which has an example at the top.

Does the log have to be completed, and ActiGraphs worn for every day of the monitoring period?

Yes, as it's important for us to get a feel for what the children do over a typical week. In our previous work we have found that once the children are into the routine of wearing the monitors, there are very few problems with getting them to keep wearing them for the duration of the week.

CHILDREN'S HEALTH, ACTIVITY AND NUTRITION: GET EDUCATED!

Child Information
Instructions for Wearing the Physical Activity Monitor

As part of CHANGE!, you have been selected to wear the physical activity monitor for seven days. The monitor is worn on an elastic belt and records activity levels throughout the day. There are no moving parts, displays, or buttons, so there is no need to switch the monitor on or off, or reset it.

Please read the following instructions carefully…

1. Collect your activity monitor

2. Put the belt on with the activity monitor positioned on the right hip. The monitor can be worn under or over your clothes. **Wear the monitor all day and take it off just before you go to bed.**

3. Each day put the activity monitor on **as soon as you get up** in the morning.

4. As the monitor is not waterproof you should take it off if you have a bath or shower, or do any water based activities, like swimming. Straight away after the activity is over, put the monitor back on.

5. If you are involved in full contact sports e.g. rugby etc. then the monitor should also be removed as it may get damaged, and could cause injury.

6. Please use the log to write down at what times of the day you first put the monitor on, when/if the activity monitor was removed and then replaced (e.g. swimming), and when you took it off for bed time.

7. Ask your parent/carer to sign the log at the end of each day when you take it off just before you go to bed.