Changes in objectively measured BMI in children aged 4-11yrs - data from the National Child Measurement Programme

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ABSTRACT

Background This study looked at the degree of weight gain between the first (Reception) and last year (Year 6) of primary school and how weight status in Reception predicts becoming overweight/obese by Year 6.

Methods A longitudinal sample of 1863 children was created using two time points (2006/7, 2012/13) from the NCMP in South Gloucestershire. T-test and logistic regression were used to test the difference between the BMI z-scores and BMI percentiles, and predict the probability of being overweight (BMI≥85th) or obese (≥95th) at Year 6 based on BMI percentile in Reception.

Results Of those children who were obese at Reception age, 68% were obese at Year 6. Compared with children with a BMI in the 2nd-49th percentile range, children between the 75th and 84th percentiles of BMI at Reception age were 10 times more likely (OR = 10.18, p<0.01), and those with a BMI between the 85th and 94th percentiles were 13 times more likely (OR = 13.38, p <0.01), to become obese by Year 6. Boys were more likely than girls to revert to a healthy weight.

Conclusion This is the first study to link data from the NCMP. It provides estimates of prevalence and offers new evidence on obesity emergence and gender differences.

Keywords: childhood obesity; obesity persistence; child health; national child measurement programme; public health

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INTRODUCTION

Rates of overweight and obesity have increased sharply in the UK since the mid-1980s[1]. The proportion of adults who were overweight or obese increased between 1993 and 2012 from 57.6% to 66.6% among men and from 48.6% to 57.2% among women. In children, there has been a steady increase in obesity in children aged 2-15 years from 11.5% in 1995 to 18.5% to 2005[2]. Despite evidence to suggest that the prevalence of obesity has stabilized in recent years, approximately one in five children start their school life either overweight or obese[3], increasing to one in three children by the last year in primary school[4].

Evidence shows that growth in early life influences later risk of obesity and that many risk factors for developing obesity originate during childhood[5,6]. It has also been widely documented that obesity in children can lead to the development of asthma, psychosocial morbidity, orthopaedic and cardiovascular problems as well as increased risk of obesity in adulthood[7]. In addition to these health risks, children who are obese have lower levels of physical fitness; suffer from discrimination; low self-esteem and lower quality of life[8].

While the evidence on obesity persisting into adulthood is well established[9,10] quantitative estimates of persistence from large contemporary cohorts in children which have used modern, accepted overweight and obesity definitions are rare[11]. The Chief Medical Officer in her recent annual report identified the need to undertake more longitudinal research that tracks individual children over time, to help identify potential predictive factors[12]. The ability to identify children at risk of developing obesity is important to mitigate future obesity incidence. A significant body of research has tracked obesity across the lifecourse. Evidence shows that a high birthweight; having one or more obese parents; maternal weight gain and early weaning are all positively associated with future weight gain[13,14,15,16]. A number of studies have looked at weight gain in pre-school children and have found this period of a child's life to be a strong predictor of obesity in adulthood[17]. Cross-sectional data from England has also demonstrated an almost linear relationship between obesity prevalence in children and the Index of Multiple Deprivation (IMD) 2010 score based on postcode[18].

In England, programmes to identify and support overweight children are currently driven by data from a surveillance programme called the National Child Measurement Programme (NCMP). The NCMP was established by the Department of Health in 2005, and involves the annual weighing and measuring of children in Reception year and Year 6 at state-maintained primary schools. This research is the first to undertake an in-depth analysis on the NCMP and retrospectively track the weights of individual children over a 7-year period. This sample is particularly appropriate for an examination of weight gain because these children were born in 2002/3, and so their growth is likely to reflect the trend of increasing overweight and obesity in England. Second, the large number of records within the NCMP dataset allows a level of detailed analysis that has not been possible in previous studies. The purpose of this research was two-fold. Firstly, it describes the level of weight gain which occurs in children between the first and last year of primary school, by gender. Although research has identified puberty as key contributor towards weight gain in older children, very few studies have examined weight gain in relation to gender during mid-childhood. The second aim was to look at the extent to which weight status in the first year of primary school predicts becoming overweight or obese by the last year of primary school.

METHODOLOGY

Ethics

Ethical approval was gained from UWE's Faculty Research Ethics Committees. Research assurance was also approved by the Avon Primary Care Research Collaborative and South Gloucestershire Council.

Data and sample

The data analysed comes from the NCMP for South Gloucestershire, England. The NCMP is recognised internationally as a world-class source of public health intelligence and holds UK National Statistics status[19]. Data on children measured during 2006/7 and 2012/13 were extracted. Measurements for children were undertaken by school health assistants or nurses using calibrated class III scales and the Leicester Height Measure MKII[19]. Coverage rates for 2006/7 and 2012/13 were 88% and 89.7% respectively.

The LMS Growth tool[20] was used to calculate BMI, BMI Standard Deviation (z-score) and BMI percentile based on gender, date of birth, date of measurement and height and weight values. Weight classifications were determined using the UK90 BMI reference curves. A deprivation score (IMD 2010) was assigned to each child based on postcode.

Matching strategy

Exact matching was employed using a string of partial identifiers to create a 'unique identifier'. This involved concatenating the variables gender, date of birth and first name. These variables were used as they were likely to be fixed from birth and rarely change during the lifetime of an individual. Any Reception records that were not matched via concatenation were matched manually. This involved identifying data entry errors where, for example, the first name may have been double-barrelled, hyphenated or misspelt.

Statistical analysis

A paired t-test was used to determine whether there was a significant difference between the BMI z-scores at the different time points. To assess whether BMI was predictive of weight status at Year 6, binary logistic regression was carried out to obtain the predicted probabilities of being overweight (BMI ≥85%) or obese (≥95%) at Year 6, on the basis of BMI at baseline (Reception year).

BMI at Reception was coded 0-1.9th, 2nd-49.9th (baseline), 50th-74.9th, 75th-84.9th, 85th-94.9th, and >95th. Separate regression analyses were performed for boys and girls, controlling for IMD. Confounding due to exact age was mitigated by BMI percentiles being used from gender- and age-specific 1990 growth charts. Ninety-five per cent confidence intervals were calculated for odds ratios (ORs). Statistical modeling was undertaken using IBM SPSS v20.

RESULTS

Data matching

Of the 2405 records that were extracted from the 2006/7 cohort, 250 records (10.4%) had missing data. Of the remaining 2155 records, 1797 records were matched automatically and 66 records were matched manually. This resulted in a total matched sample of 1863 records (78.7%).

Sample characteristics

Of the matched sample, 968 were boys and 985 were girls. At the first measurement (Reception), the mean age for all children was 4.94 years (SD 0.33); 4.95 (SD 0.33) for boys and 4.94 (SD 0.33) for girls. At the follow-up measurement (Year 6), the mean age was 10.64 years (SD 0.38); 10.64 (SD 0.44) for boys and 10.65 (SD 0.30) for girls (see Table 1).

Table 1. Sample characteristics for calculating change in weight status

	Reception			Year 6		
	All n=1863	Boys n=968	Girls n-895	All n=1863	Boys n=968	Girls N=985
Age						
Mean	4.94	4.95	4.94	10.64	10.64	10.65
SD	0.33	0.33	0.33	0.38	0.44	0.30
BMI z-score						
Mean	0.30	0.33	0.28	0.44	0.47	0.40
SD	0.99	1.00	0.97	1.13	1.10	1.16

Changes in BMI z-scores

BMI z-scores increased between Reception and Year 6 (see Figure 1). The mean BMI z-score at Reception was 0.30 (SD 0.99) and 0.44 (SD 1.13) at Year 6 (0.14, CI 0.09-0.18, p<0.01). The mean BMI z-score for boys at Reception age was 0.33 (SD 1.00) and 0.47 (SD 1.10) at Year 6 (0.15, CI 0.03—0.03, p<0.01). The mean BMI z-score for girls at Reception age was 0.28 (SD 0.97) and 0.40 (SD 1.16) at Year 6 (0.13, CI 0.07-0.19, p<0.01).

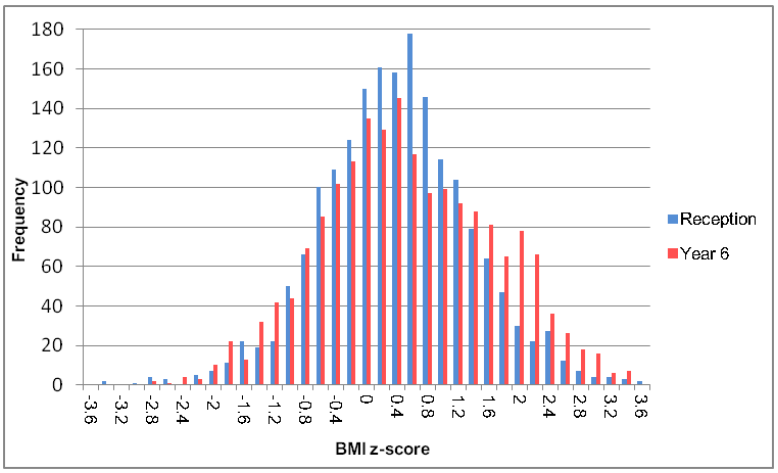

Figure 1: Fig. 1 Frequency distribution of BMI z-score for Reception and Year 6 children.

Changes in percentiles of BMI

Analysis of changes in BMI percentiles between Reception and Year 6 found a decrease in the proportion of children whose BMI was between 50 and 74th percentiles from 29.8% [95% 27.8-31.9] at Reception to 22.8% [95% 21-24.8] at Year 6. This difference was statistically significant for girls but not for boys. A statistically significant increase was also observed in the proportion of children with BMI over the 95th percentile from 8.2% [95% CI 7.0-9.5] to 16.3% [95% CI 14.6-18.1]. When examining differences between genders, it was found that there was a statistically significant decrease in the proportion of girls who fell within 50th-74.9th percentile, but the difference was not significant for boys.

Changes in weight status

At Reception age, 1.1% [95% CI 0.5-1.5] of the children were underweight, 77.8% were a healthy weight [95% CI 75.9-79.6], 12.9% [95% CI 11.5-14.5] were overweight and 8.2% [95% CI 7.0-9.5] were obese (total overweight and obese = 21.1%). By Year 6, there was a decrease in prevalence of healthy weight to 68.7% [95% CI 66.6-70.8, p<0.05) and an increase in prevalence of obesity to 16.3% [95% CI 14.6-18.1, p<0.05).

Emergence and remission of overweight/obesity

Of those children who were obese at Reception age, 68% remained obese, 16.3% had become overweight and 15.7% achieved a healthy weight by Year 6. Of those children who were overweight at Reception, 27% remained overweight, 30.3% had become obese and 42.7% achieved a healthy weight by Year 6. Of those children who were a healthy weight at Reception, 78.4% remained so, 11.7% had become overweight and 8.8% became obese by Year 6 (see Table 2). No children who were overweight or obese at Reception age became underweight at Year 6. Equally, no children who were underweight at Reception went on to become overweight or obese at follow-up. Approximately one third of girls who were overweight at Reception age remained overweight at Year 6 (32.1%) and another third (34.8%) went on to become obese by Year 6. These figures were lower for boys - approximately a quarter (22.5%) of those were overweight at Reception remained in that category in Year 6, and another quarter (26.3%) had become obese.

Table 2: Change in weight status between Reception and Year 6 for the whole sample, boys and girls using British 1990 (UK90) growth reference charts

Baseline (Reception)	Follow-up (Year 6)							
	underweight		healthy weight		overweight		obese	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Underweight	3	15	17	85	0	0	0	0
Healthy Weight	16	1.1	1136	78.4	170	11.7	127	8.8
Overweight	0	0	103	42.7	65	27	73	30.3
Obese	0	0	24	15.7	25	16.3	104	68
Baseline (Reception boys n=968)	Follow-up (Year 6 boys)							
	underweight		healthy weight		overweight		obese	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Underweight	1	7	13	93	0	0	0	0
Healthy Weight	7	1	577	78.6	81	11	69	9.4
Overweight	0	0	66	51.2	29	22.5	34	26.3
Obese	0	0	15	16.5	16	17.6	60	65.9
Baseline (Reception girls n=895)	Follow-up (Year 6 girls)							
	underweight		healthy weight		overweight		obese	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
underweight	2	33.3	4	66.6	0	0	0	0
healthy Weight	9	1.3	559	78.2	89	12.4	58	8.1
overweight	0	0	37	33.1	36	32.1	39	34.8
obese	0	0	9	14.5	9	14.5	44	71

Predicting childhood obesity

The results of logistic regression models for overweight and obesity in Year 6, controlling for deprivation, are shown in Table 3, both for all children and by gender. Those children whose BMI at Reception was between the 85th and 94.9th percentile (overweight) were 13 times more likely to become overweight or obese at follow-up compared with those whose BMI at Reception was in the baseline category (2nd-49.9th percentile) (p<0.05). Those children whose BMI at Reception was between the 75th and 84.9th percentile (upper healthy weight range) were 10 times more likely to become overweight or obese at follow-up compared with those whose BMI at Reception was in the baseline category (2nd-49.9th percentile) (p<0.05).

The results of separate logistic regression models for boys and girls (Table 3) indicate that BMI at Reception is more strongly associated with BMI at Year 6 in girls than in boys for all percentile ranges. For example, the OR for BMI in the 75th and84.9th percentile range was 9 for boys and 11 for girls. For the 85th and 94.9th percentile range it was 9 for boys and 20 for girls.

When using obesity (BMI >95th percentile) as the outcome measure at Year 6, those children whose BMI at Reception was between the 75th and 84.9th percentile were six times more likely to become obese at follow-up compared to those whose BMI at Reception was in the baseline category (2nd-49.9th percentile) (p<0.05). Those children whose BMI at Reception was between the 85th-94.9th percentile were 11 times more likely to become obese by Year 6. For boys the ORs were again lower than for girls (see Table 3).

Deprivation and obesity

Cross-sectional analysis confirmed a positive association between deprivation and obesity at both Reception and Year 6. We observed a higher proportion of obese children in the most deprived quintile at both Reception (10.7%, 95% CI 7.8-14.5) and Year 6 (17.5%, 95% CI 13.8-21.91) compared with those in the lowest quintile at Reception (7.6%, 95% CI 5.5-9.71) and Year 6 (13.4%, 95% CI 10.5-17.01). This trend was mirrored across boys and girls. Overall, the coefficients for deprivation in the multivariate model did not indicate a statistically significant effect of IMD score on the odds of becoming overweight or obese at Year 6, given weight status at Reception. However, there was some evidence of an association between deprivation and weight gain in girls with a 2% increase in the odds of becoming overweight or obese for every increment of 1 in the IMD (deprivation) score (p=0.05).

Table 3 Odd ratio's (95% CI) of Year 6 BMI >85th percentile (overweight or obese) and BMI >95th percentile (obese) as predicted by Reception BMI ranges, adjusted for deprivation (IMD2010 score)

Odd ratio's (95% CI) of being overweight or obese in Year 6 (BMI >85th percentile), adjusted for deprivation (IMD2010)									
	All			**Boys**			**Girls**		
Variable	All N=1863	95% CI	P-value	All N=968	95% CI	P-value	All N=895	95% CI	P-value
BMI ≤1.9	-*	-*	-*	-*	-*	-*	-*	-*	-*
BMI 2-49.9	(ref)	(ref)	(ref)	(ref)	(ref	(ref)	(ref)	(ref)	(ref)
BMI 50-74.9	3.21	1.91-5.40	0.00	2.60	1.28-5.27	0.08	3.86	1.78-8.40	0.01
BMI 75-84.9	10.18	5.98-17.34	0.00	9.23	4.59-18.76	0.00	11.03	4.87-24.95	0.00
BMI 85-94.9	13.38	8.00-22.38	0.00	8.90	4.42-17.97	0.00	20.11	9.32-43.42	0.00
BMI 95+	65.27	37.59-113.35	0.00	50.14	24.35-103.26	0.00	90.28	38.17-213.55	0.00
Deprivation Score	1.02	1.00-1.03	0.09	1.02	0.99-1.04	0.13	1.02	0.99-1.04	0.25

Odd ratio's (95% CI) of being obese in Year 6 (BMI >95th percentile), adjusted for deprivation (IMD2010)									
	All			**Boys**			**Girls**		
Variable	All N=1863	95% CI	P-value	All N=968	95% CI	P-value	All N=895	95%	P-value
BMI ≤1.9	-*	-*	-*	-*	-*	-*	-*	-*	-*
BMI 2-49.9	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
BMI 50-74.9	2.40	1.76-3.28	0.00	2.53	1.32-3.20	0.02	2.70	1.73-4.21	0.00
BMI 75-84.9	6.40	4.43-9.12	0.00	5.81	3.55-9.50	0.00	6.97	4.09-11.87	0.00
BMI 85-94.9	10.78	7.58-15.33	0.00	6.99	4.30-11.37	0.00	17.23	10.17-29.20	0.00
BMI 95+	43.16	26.21-71.08	0.00	38.31	19.91-73.03	0.00	50.30	22.86-110.65	0.00
Deprivation Score	1.02	1.01-1.04	0.11	1.02	1.00-1.04	0.04	1.02	1.00-1.04	0.05

* No children who were ≤1.9 percentile for BMI at Reception age were obese at Year 6; thus, ORs could not be calculated for the Reception period.

DISCUSSION

Main findings of this study

Data from this study mirrors findings from national data showing that obesity prevalence approximately doubles between the first and last years of primary school. Our findings provide little reassurance that those children who are obese in early childhood 'grow out of' excess adiposity. Including overweight, we found that 84% of obese children at Reception year went on to be either overweight or obese by Year 6.

Odds ratios of being overweight (BMI ≥85th percentile) or obese (≥95th percentile) based on BMI at Reception are similar to published literature[21]. As expected, children who were identified as overweight or obese at Reception were more likely to remain so at Year 6. Furthermore, the data indicate that children who are within the upper range of the healthy weight category (75th-85th percentile) at Reception have an increased risk of being overweight or obese by the time they reach Year 6. More boys than girls dropped a weight category (from overweight or obese) by the time they reached Year 6, and this was reflected in the odds ratios of becoming obese. Interestingly, previous studies have failed to identify any significant differences in BMI change between boys and girls during mid-childhood[22] Explaining why some children gain weight and become obese, whereas others maintain a healthy weight, has proved challenging but deprivation has been shown to be a good predictor of obesity and weight gain[23]. Although our findings reflect national data showing a higher proportion of obese children in poorer areas compared with more affluent areas, we did not find strong

statistical evidence of an association between deprivation and weight gain. The small amount of variability with our data could be explained by South Gloucestershire being a relatively affluent geographic area (low levels of deprivation) compared with the whole of England and Wales.

What is already known on this topic?
Very little longitudinal research has been conducted looking at the emergence and remission of obesity during using modern and reliable datasets. Only a handful of studies in the UK have looked at the emergence of and persistence of obesity in mid-childhood. Persistence of obesity found in this study (67%) is consistent with UK studies which found that 68% and 75% of children remained obese between the ages of 7 and 11 years [24,25]. A number of studies have examined the link between weight gain and deprivation and have found a higher prevalence of overweight and obesity amongst children of lower socio-economic status[26].

What this study adds
This is the first study to link data from a cohort of children via the National Child Measurement Programme in England. It shows that a significant number of children gain weight between the first and last year of primary school and that obesity persistence is high. Our results indicate that girls are less likely to revert to a healthy weight status.

These findings suggest that parents and health professionals should be more vigilant in recognizing children at risk of becoming obese. Focusing preventative efforts towards children who are likely to be on the path to obesity is important. Raising the potential risks with parents in terms of healthy growth is crucial to prevent future health problems, particularly as evidence suggests many parents and health professionals underestimate obesity in children and its importance[27,28]. Current NCMP guidance recommends feedback to all parents around the four different weight categories (underweight, healthy weight, overweight and obesity). This study indicates that health providers should place more emphasis on tailoring feedback based on a child's percentile rather than weight category, in particular highlighting that those children at the upper end of the healthy weight range are likely to increase their BMI if a healthy lifestyle is not adhered to.

The design of the NCMP means that children are measured at 7-year intervals. It has been proposed that measuring children on a more frequent basis could enable early identification of obesity[29]. This could be particularly important as research suggests that most weight gain occurs between 7 and 9 years of age[30]. However, implementing routine BMI checks in children could be problematic with the NCMP programme already facing criticism by parents with concerns about the effect on their children's self-esteem; therefore changing policy may prove difficult[31]. This is further compounded by recent research that has questioned the effectiveness of feedback to parents on their children's weight and its influence on health-related behaviour[32].

The results of this study should be a major concern for policy makers, as the observed increase in prevalence of obesity amongst primary school children occurred during a period of significant investment by the Government aimed at promoting healthy lifestyles. This investment involved the creation of a National Healthy Schools Programme to support children and young people to develop healthy behaviours using a whole-school approach. Additional investment was made in school sport with the establishment of school sport partnerships between 2000 and 2012 to increase participation in physical activity.

Limitations of this study
This study has a number of strengths: longitudinal design; large and contemporary sample size; and objective measures of BMI. It is the first study in the UK to analyse the persistence of obesity in a cohort of children measured by the NCMP. However, attrition resulted in only 79% of records being matched. Anecdotal evidence suggests that very overweight children are more likely to opt out of being measured than other children[33]. Analyses on national NCMP data performed in 2007/08 and repeated subsequently concluded that a lower participation rate may lead to an underestimation of obesity prevalence in Year 6, but had little or no effect on prevalence in Reception[34]. Nevertheless, when compared with South Gloucestershire's recorded obesity prevalence at the time for Reception and Year 6[35] we found that obesity rates in our matched sample were 1.5% lower in 2006/7 and 0.5% lower in 2012/13[36].

Previous studies have argued that using BMI as a measure of body fatness could be problematic as it fails to account for factors such as muscle mass and puberty, which can alter the relationship between BMI and body fatness. A recent systematic review estimated that using BMI may lead to 25% of children being missed who have excess body fat[37]. However, using BMI at a population level is seen as relatively robust[38]. Our model did not account for ethnicity, whereby certain ethnic minority groups are known to be more susceptible to developing obesity[39]. However, the proportion of black and minority ethnic children aged 5-9 years in South Gloucestershire is approximately a third (7.4%) of the national average (22.6%) and therefore the impact will likely be negligible.

CONCLUSION
Previous research has shown that weight status tracks from childhood to adulthood[,10], therefore many of the overweight and obese children in this sample will become obese adults and this will have a significant impact on their future health[40]. Therefore early identification and a focus on prevention for those children who are likely to become obese are important. While these results demonstrate that persistence of obesity in mid-childhood is common, just under a half of overweight children and a sixth of obese children managed to drop a weight category by the time they reached 10/11 years of age. It is therefore important that further research is undertaken to explore what strategies led these children to achieve a positive shift in weight status.

CONTRIBUTORS

Matthew Pearce was the lead researcher and author. **Sarah Webb-Phillips** extracted the data and provided support with the matching strategy. **Dr Isabelle Bray** supported statistical analysis.

COMPETING INTERESTS

Authors have declared that no competing interests exist

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