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Prevalence and trends in overweight and obesity in childhood and adolescence

Findings from the Millennium Cohort Study, with a focus on age 14

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Introduction

The sixth sweep of the Millennium Cohort Study (MCS) was carried out between January 2015 and March 2016, when respondents were aged 14, corresponding to Year 9 in England and Wales, Year S3 in Scotland, and Year 10 in Northern Ireland[2]. Interviews were conducted with 11,726 families and survey respondents included both cohort members and their parents. The survey combined both interviewer administered and self-completion instruments, as well as direct measurements of young people's physical growth, and assessments of both young people and their parents' cognitive ability.

In this paper, we focus on overweight and obesity of the cohort members, and in particular, we look at prevalence and trends from early childhood (age 3) to age 14. The MCS has gathered information on the physical development and growth of its cohort members at every sweep since age 3, making it a unique, nationally-representative resource for the study of childhood overweight and obesity. We take advantage of the multidisciplinary nature of the study to investigate factors that influence children's physical development.

Childhood overweight and obesity is a growing concern in the majority of industrialised nations, and the childhood obesity and overweight epidemic is growing globally, with large variations in secular trends across countries (Wang & Lobstein, 2006). Globally, the prevalence of overweight and obesity combined has risen by 47.1% for children between 1980 and 2013 (compared to 27.5% for adults). Remarkable increases have been observed in developed countries since 1980, with 23.8% of boys and 22.6% of girls being either overweight or obese in 2013 compared to 16.9% of boys and 16.2% of girls in 1980. Gender differences in the levels and trends of overweight and obesity are small (Ng et al., 2014).

In the UK, research on school-aged children, spanning 1974 to 1998 (Chinn & Rona, 2001; Lobstein, James, & Cole, 2003) found that in 1998 prevalence of overweight boys and girls aged 7–11 years was 17% and 23.6% respectively. This represented an increase of 60% since 1994 and 150% since 1974. In England, the period 1995 to 2005 witnessed a general increase in childhood obesity from around 12% to 18%,

[2] The sixth sweep of MCS was core-funded by the Economic and Social Research Council (ESRC), and co-funded by the following consortium of government departments: Department for Education, Department of Health, Ministry of Justice, Home Office, Department for Transport, Department of Work and Pensions, Welsh Government and Department for Employment and Learning (Northern Ireland).

which has since levelled off (Conolly 2016). This same recent, Health Survey for England found that 28% of children aged 2 to 15 were either overweight (14%) or obese (14%). Among children in early adolescence, aged 11 to 15, the estimated prevalence of obesity has been between 16% and 20% between 2008 and 2015. Findings from this same study, the Millennium Cohort Study, show a stark increase in rates of obesity between ages 7 and 11, from 13% to 20% (Connelly and Chatzitheochari 2014).

Children who are overweight or obese face an increased risk of many health problems, including asthma (Lang, 2012), cardiovascular disease (Bridger, 2009), type 2 diabetes (Pulgaron & Delamater, 2014), cancer (Renehan et al, 2008), osteoarthritis, and chronic kidney disease (Asia Pacific Cohort Studies Collaboration, 2004; Wormser et al., 2011). Johnson et al (2015) show that younger generations are likely to accumulate greater exposure to overweight or obesity throughout their lives. Cohorts born after the 1980s already have probabilities of overweight or obesity in childhood that are two to three times greater than those for cohorts born before the 1980s (Johnson et al., 2015). As a consequence, they have increased risk for chronic health conditions such as coronary heart disease and type 2 diabetes mellitus. Childhood overweight and obesity is associated with psychological problems such as low self-esteem and depression, and can have a major and enduring impact on an individual's life (Russell-Mayhew, McVey, Bardick, & Ireland, 2012). Overweight and obesity in childhood is also a predictor of overweight and obesity in adulthood (Guo, Wu, Chumlea, & Roche, 2002). In monetary terms, the overall cost of obesity to wider society is estimated at £27 billion per year. The UK-wide NHS costs attributable to overweight and obesity are projected to reach £9.7 billion by 2050, with wider costs to society estimated to reach £49.9 billion per year (Public Health England, 2017). As part of its Childhood Obesity Plan (HM Government, 2017), the government aims to 'significantly reduce England's rate of childhood obesity within the next ten years'. Its first major step towards this is the introduction of a UK-wide soft drinks industry levy, which will come into effect in April 2018. Public Health England has also formulated a sugar reduction plan, which aims to reduce overall sugar content across a range of key products that contribute to children's sugar intakes by at least 20% by 2020.

In this paper we analyse objective data on BMI and overweight/obesity status among adolescents aged 14 in 2015. The aims of the paper are threefold. First, we show trajectories in overweight and obesity in the UK, for today's current generation of adolescents, since early childhood. Second, we identify factors that are positively and negatively associated with the risk of overweight and obesity at age 14, and third, we

study transitions into and out of overweight/obese statuses, from early adolescence (age 11) to mid-adolescence (age 14), an important transitional stage when individuals increase significantly in their autonomy and independence (Wray-Lake, Crouter, & McHale, 2010). The overarching aim is to inform policy by providing up to date evidence on the current risk of overweight and obesity of adolescents, alongside understanding the factors affecting changes in weight status over time.

Methods

Sample

Amongst the 11,726 families interviewed at age 14, 11,872 children participated in this sixth survey.[3] In this report, we exclude twins and triplets, resulting in a sample of 11,714 respondents. The choice was made to avoid the problem of non-independence of observations, and justified by the very modest number of twins/triples in the sample (1.33%). Individuals had their weight, height and body fat measured in the home by the interviewer, following well-established protocols (Fitzsimons, 2017). BMI is constructed from height and weight data (BMI=weight/height squared; further detail follows below). 739 (6.4%) of the 11,564 respondents did not provide valid measure of BMI, therefore information on BMI is available for 10,825 singleton children. All results are based on this sample. In multivariate cross-sectional analyses, only respondents having complete records of predictors of overweight and obesity are included and sample size slightly reduces (N=10,056, see Table 3). When considering transitions from age 11 to 14, the sample consists of respondents taking parts in sweep 5 and 6 (N=10,120).

To maximize the representativeness of MCS across sweeps we use survey weights. Two types of weights are available in MCS, cross-sectional and longitudinal (Mostafa & Ploubidis, 2017). The former maximize representativeness of each sweep as standalone study, the latter also account for non-response due to attrition. The choice of which weight we use depends on the type of analysis. For all descriptive statistics we use cross-sectional weights (results presented in Figures 1 to 4, Tables 1 and 2); linear probability models for overweight at age 14 and transition analyses are performed using longitudinal weights (Tables 2 to 8).

[3] Six surveys (sweeps) of the study have taken part so far: at ages 9 months, 3, 5, 7, 11 and 14 years, referred to interchangeably as sweeps 1 through 6.

BMI classification

BMI is the most frequently used measure for child obesity prevalence in the UK. Children are normally classified as overweight or obese by comparing their BMI with a reference population that describes the distribution of BMI within a population by age and sex. This is necessary because a child's BMI changes with age and sex so fixed thresholds, as applied to adults (30 and 25 kg/m2) cannot be used. There are several published thresholds and reference populations to which a child's BMI can be compared. The most widely used methods used in the UK are cut-offs based on the UK1990 growth reference and the international classification system commonly referred to as the International Obesity Task Force (IOTF) cut-offs. Each is briefly described in Appendix 1. Most published prevalence figures in the UK are based on the population surveillance thresholds of 85th and 95th centiles of the UK1990 growth reference. These thresholds are based on the assumption that around 15% (5%) of the baseline population are overweight (obese). UK1990 is recommended by the Scientific Advisory Committee on Nutrition (2012); the IOTF cutoff points are recommended for use in international comparisons of prevalence of overweight and obesity (Tim J Cole, Bellizzi, Flegal, & Dietz, 2000). In this paper, we use the UK1990 system for classification.

In this paper, we consider overweight and obesity combined (referred to as "excess weight"), as well as focusing on obesity only, given its policy interest and relevance. Underweight was combined with normal weight due to its very low prevalence[4]

Descriptive statistics

We first show the prevalence of overweight and obesity at age 14, in Table 1 below, separately for males and females. The table shows that around 20% of 14 year olds are classified as obese, with the proportions very similar across males and females. 13% of males and 16% of females are classified as overweight, with proportions classified as normal weight slightly lower amongst females (63.6%) than males (65.9%). So on the whole, we see high levels of excess weight, with only small differences across gender.

[4] There is little consensus in the use of health related cut offs for thinness, especially among children. Cole and colleagues (2007) produced cut-off points to apply for children and adolescence. Thinness grades 2 and 3 are considered moderate and severe thinness respectively, grade 1 is considered mild thinness. In our sample, total proportion of underweight ranged from 9% at age 3 to 4.6% at age 5, prevalence of grades 2 and 3 were never higher than 2.5% (see Table A1 in the Appendix).

Table 1. Overweight and obesity at age 14, by sex

	Males		Females		Total	
	N	%	N	%	N	%
Normal weight	3,656	65.9	3,422	63.69	7,078	64.86
Overweight	748	13.35	857	15.98	1,605	14.59
Obese	1,095	20.76	1,046	20.33	2,141	20.56

Proportions based on cross-sectional sample at sweep 6 with complete records on weight and height. N based on those with complete BMI records at age 14.

We next look at how these proportions compare to earlier childhood. We first show the prevalence of overweight and obesity from age 3 to age 14 in Figure 1.[5] Both overweight and obesity increase as respondents grow up. In particular, we observe a stark increase between ages 7 and 11, with overweight raising from 11.9% to 15.2% and obesity even more dramatically, from 12.7% to 20.2%. In early childhood, children tend to be more overweight than obese; then in early adolescence the proportions reverse and proportions classified as obese are higher than proportions classified as overweight.

Figure 1. Overweight and obesity, by age[a]

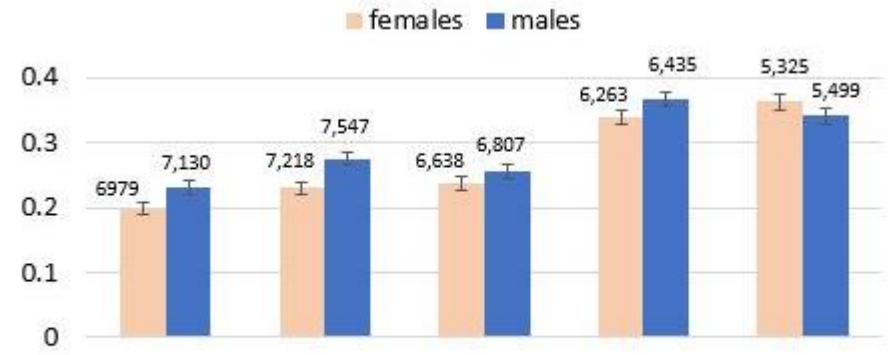
[a] Proportions based on cross-sectional samples ($N_{age\ 3}$=14,109; $N_{age\ 5}$=14,765; $N_{age\ 7}$ =13,445; $N_{age\ 11}$ =12,698; $N_{age\ 14}$ =10,824)

Figure 2 illustrates prevalence in excess weight from age 3 to 14, with 95% confidence intervals, by gender. It shows that trends in excess weight are increasing for both males and females, with lower proportions of overweight/obese females compared to males

[5] For cross-sectional analysis we chose to maximize the sample size at each sweep, and therefore selected respondents with complete records on weight and height in the specific sweep, without considering the longitudinal consistency of measures.

until age 11 and then at age 14, 36.3% of females are overweight/obese compared to 34.1% of males.

Figure 2. Excess weight, by age and sex



Cross-sectional sample sizes by gender reported within the figure. Excess weight includes overweight and obesity.

Figure 3, in which obesity and overweight and distinguished, illustrates similar patterns. The most stark finding is the sharp rise in obesity between ages 7 and 11, for both males and females, with noteworthy though smaller increases in overweight during this period. Between 11 and 14, weight changes are less apparent, though proportions of overweight and obesity decline slightly among males, and increase slightly among females.

Figure 3. Overweight and obesity, by age and sex

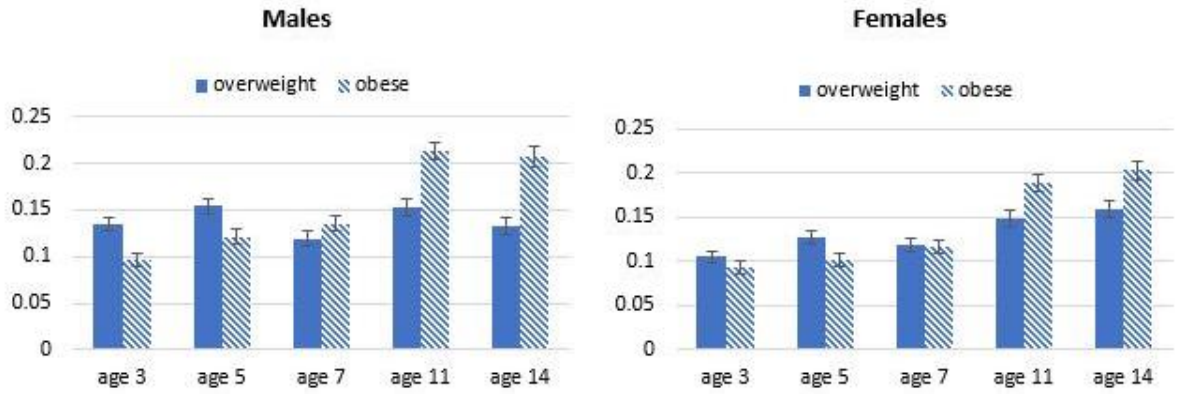
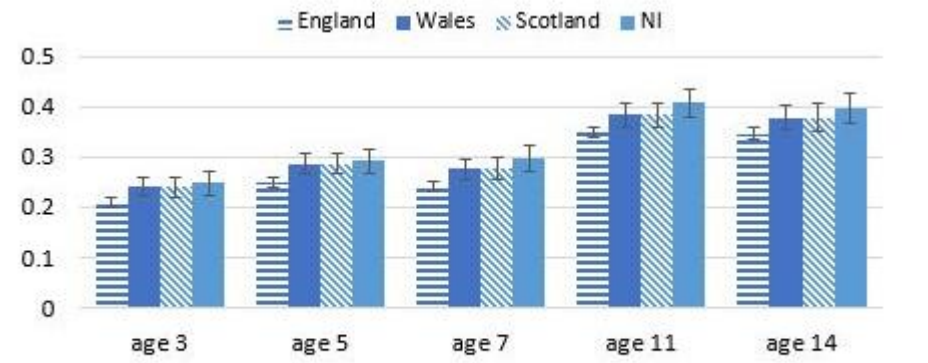


Figure 4 presents proportions with excess weight from age 3 to 14, with 95% confidence intervals, by country. Trajectories are similar across countries. At each age, the lowest proportions of excess weight are observed in England and the highest in Northern Ireland. At age 14, proportions range from 0.347 in England to 0.399 in Northern Ireland, and these differences are significantly different from each other at 5% level.

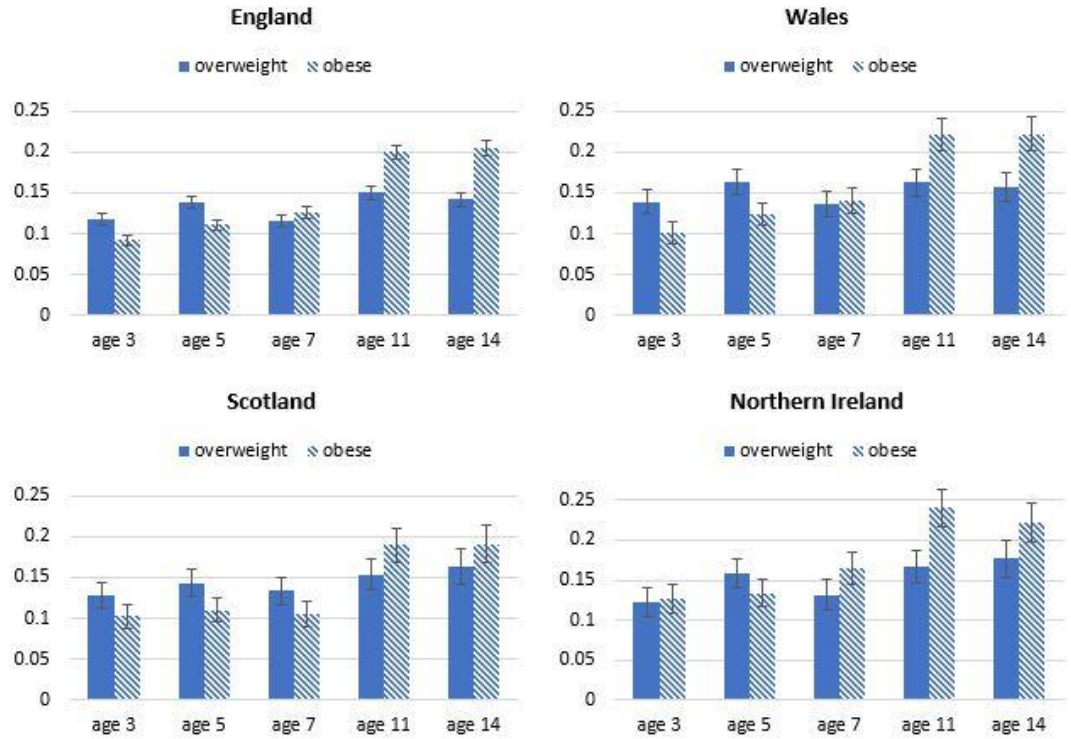
Figure 4. Excess weight, by ages and country[a]



[a] Proportions are based on cross-sectional samples and weighted with cross-sectional weights.

Distinguishing overweight and obesity (Figure 5), the comparisons between countries are substantively similar, but we also see that Northern Ireland has the highest prevalence of both overweight and obesity, with obesity being particularly more predominant, while Scotland has the lowest prevalence of obesity at each age.

Figure 5. Overweight and obesity, by age and country[a]



[a] Proportions are based on cross-sectional samples and weighted with cross-sectional weights.

Analysis

Predictors of overweight and obesity at age 14

In this section, descriptive statistics of overweight and obesity at age 14 are presented by categories of predictive factors including child's characteristics -ethnicity and sex, country and maternal education. When deriving overweight and obesity from BMI, in order to be consistent with previous studies and aid comparability, we do not consider ethnic-specific BMI cut-points, although there is recent evidence suggesting the importance of considering ethnic differences in body composition when developing BMI cut-points, especially for Asian children (Liu et al., 2011).

All factors are basic sociodemographic characteristics and early life factors known to be associated with risk of overweight in childhood (Massion et al., 2016). They are all measured at the first survey, when respondents were aged 9 months. Results are presented in Table 2. The most striking differences are those observed by ethnicity and maternal education. For instance, 48% of Black children are classified as having excess weight at age 14, compared to 34.5% of White children. Regarding maternal education, almost 40% of children of mothers with GCSE or lower qualification are classified as having excess weight, compared to 14% amongst those whose mother has a degree or higher.

Table 2. Excess weight, and overweight and obesity at age 14: descriptive statistics

Factors		N[a]	% excess weight	p-value[b]	% over-weight	% obese	p-value[b, c]
Sex	Male	5083	34.7	0.102	13.5	21.1	0.004
	Female	4973	36.1		16.1	20.0	
Ethnicity	White	8109	34.5	<0.001	15.2	19.7	<0.001
	Mixed	458	32.3		13.8	18.4	
	Indian	259	38.2		13.1	22.5	
	Pakistani and Bangladeshi	694	40.5		12.3	28.9	
	Black or Black British	294	48.1		20.4	29.6	
	Other Ethnic group	242	36.2		12.4	24.7	
Maternal education	No academic/Other academic w/ voc>=L3	1620	38.7	<0.001	13.86	24.9	<0.001
	GCSE D-G w/ voc>=L3+ GCSE D-C or less	1182	39.9		13.62	26.3	
	GCSE A-C & A lev w/ voc>=L3	3912	36.3		15.94	20.4	
	A lev + voc>= L3 & diplomas in HE	1307	31.3		14.69	16.6	
	degree or higher degree	2035	26.3		13.85	12.5	
Country	England	6478	34.8	0.006	14.4	20.5	0.009
	Wales	1444	38.7		15.5	23.2	
	Scotland	1131	35.9		17.0	19.0	
	Northern Ireland	1003	39.3		16.5	22.8	

Proportions measured using cross-sectional weights at sweep 6

[a] N based on respondents having complete records on all variables included in the model presented in table 3.

[b] Significance of differences across classes is tested using chi-square test, performed on the unweighted sample.

[c] In the chi-square test, overweight and obesity are treated as a categorical variable.

We next estimate a linear probability model to understand the factors associated with overweight or obesity, adjusting for background confounders. We estimate two models. In the first, the outcome is a binary indicator of whether respondent displayed excess weight at age 14; in the second model, obesity at age 14 is the dependent variable. Independent variables include those shown in Table 2 and other factors known to be associated with excess weight: birthweight, whether the child had been breastfed at least 90 days, parental and household characteristics (whether mother regularly smoked when the child was 9 months old, number of siblings in the household, single parent household, home ownership). We note that the models estimate associations between variables, and cannot be interpreted as causal.

Table 3 presents the coefficients and standard errors from these models. Looking first at predictors of excess weight at age 14, we see that having been breastfed for at least 90 days, home ownership and high maternal education are all protective factors against excess weight at age 14. In line with the unadjusted statistics in Table 2, children from Indian, Pakistani and Bangladeshi and Black ethnic backgrounds have a

higher probability of being overweight/ obese compared to White children. Birth weight is positively associated with the probability of excess weight at age 14, with a unit (kg) increase in birth weight predicting a 6.1 percentage point increase in the probability of excess weight at age 14. Although some of the results are statistically significant, we cannot claim any causal association between predictors and outcome based on this model.

Turning to obesity, we see that the predictors are similar to those described above, though magnitudes of the associations are even larger. For instance, ethnic differences are more stark, with ethnic minorities considerably more likely to be obese compared to White children; the same is true of maternal education where for instance children of those with a degree or higher are 9.7 (4.8) percentage points less likely to be obese compared to those with no formal qualification.

Table 3. Linear probability models, dependent variables: excess weight at age 14, and obesity at age 14

Predictive factors		Excess weight		Obesity	
		β	S.E.	β	S.E.
		(1)	(2)	(3)	(4)
Sex (ref. female)		-0.024**	(0.010)	0.011	(0.016)
Ethnicity (ref. White)	Mixed	-0.021	(0.021)	-0.036	(0.036)
	Indian	0.097***	(0.034)	0.138**	(0.057)
	Pakistani, Bangladeshi	0.129***	(0.024)	0.269***	(0.041)
	Black or Black British	0.158***	(0.025)	0.203***	(0.043)
	Other ethnic group	0.034	(0.031)	0.110**	(0.052)
Birth weight		0.060***	(0.008)	0.084***	(0.014)
Breastfed 90+ days		-0.044***	(0.012)	-0.073***	(0.020)
Mother smoked when child was 9 months		0.045***	(0.011)	0.074***	(0.019)
Mother's education (ref. no academic qualification)	GCSE D-G w/ voc>=L3+ GCSE D-C or less	0.024	(0.017)	0.061**	(0.028)
	GCSE A-C & A lev w/ voc>=L3	0.013	(0.014)	-0.012	(0.023)
	A lev + voc>= L3 & diplomas in HE	-0.017	(0.019)	-0.047	(0.033)
	degree or higher degree	-0.049***	(0.018)	-0.097***	(0.031)
Number of siblings		-0.030***	(0.004)	-0.036***	(0.007)
Single parent household		-0.004	(0.012)	0.012	(0.020)
Own house		-0.085***	(0.012)	-0.145***	(0.020)
Country (ref. England)	Wales	0.041*	(0.021)	0.061*	(0.036)
	Scotland	0.016	(0.017)	-0.013	(0.028)
	Northern Ireland	0.060***	(0.023)	0.073*	(0.039)
Observations		*10,056*		*10,056*	

The regression is weighted using longitudinal weights for non-response adjustment.

*** p<0.01, ** p<0.05, * p<0.1

We also estimate a multinomial model to understand the factors affecting overweight and obesity separately, relative to normal weight. Relative risk ratios are presented in

Table 4. A risk ratio>1 (<1) suggests an increased (decreased) risk of that outcome in the exposed group. So for instance, we see that being male decreases the probability of being overweight, but not obese, relative to being normal weight. More broadly, we do not find any major differences in predictors of overweight and predictors of obesity – they share much common ground. Breastfeeding, home ownership and number of siblings are associated with a lower probability of being overweight or obese, compared to being normal weight. Education differences are somewhat more discernible for obesity, with the least (most) educated displaying a higher (lower) probability of obesity compared to normal weight, but no such pattern for overweight.

Table 4. Multinomial logistic regression, dependent variable: categorical overweight [a] at age 14

		P(overweight)		*P(obesity)*	
		RRR[b]	**S.E.**	**RRR[b]**	**S.E.**
Sex (ref. female)		0.790***	(0.074)	0.989	(0.053)
Ethnicity (ref. white)	Mixed	0.942	(0.127)	0.879	(0.107)
	Indian	1.418*	(0.288)	1.648***	(0.296)
	Pakistani, Bangladeshi	1.171	(0.190)	2.262***	(0.272)
	Black or Black British	1.882***	(0.279)	2.063***	(0.264)
	Other ethnic group	0.890	(0.187)	1.362*	(0.217)
Birth weight		1.253***	(0.066)	1.366***	(0.064)
Breastfed 90+ days		0.884*	(0.065)	0.752***	(0.0525)
Mother smoked when child was 9 months		1.136*	(0.079)	1.287***	(0.078)
Mother's education (ref. no academic qualification)	GCSE D-G w/ voc>=L3+ GCSE D-C or less	0.995	(0.105)	1.182**	(0.099)
	GCSE A-C & A lev w/ voc>=L3	1.158*	(0.099)	0.997	(0.072)
	A lev + voc>= L3 & diplomas in HE	1.019	(0.121)	0.857	(0.092)
	degree or higher degree	0.931	(0.107)	0.672***	(0.072)
Number of siblings		0.876***	(0.025)	0.872***	(0.021)
Single parent household		0.930	(0.066)	1.02	(0.062)
Own house		0.797***	(0.057)	0.619***	(0.039)
Country (ref. England)	Wales	1.149	(0.147)	1.236*	(0.138)
	Scotland	1.180*	(0.116)	0.988	(0.093)
	Northern Ireland	1.296*	(0.179)	1.316**	(0.162)
Observations		*10056*		*10056*	

[a] Reference category: normal weight
[b] RRR=relative risk ratio

Transitions between ages 11 and 14

Changes in normal weight and overweight or obesity status are studied distinguishing changes from late childhood (age 11) to adolescence (age 14). This is to understand pathways out of and into overweight between these important lifecycle stages. We chose this transition as particularly policy relevant, representing the move from primary

to secondary school, and an important shift in autonomy and decision making, with young people taking on more of their own decisions around health, nutrition, and exercise.

We first present transition matrices for normal weight and overweight or obesity status between age 11 and 14, from the period of late childhood to adolescence. We next run linear probability models to examine predictors (*X*) of improvements in weight status - from overweight or obese to normal weight - as below:

$$\Pr(normal\ weight_{14} = 1 | normal\ weight_{11} = 0) = f(X) \quad (1)$$

Similarly, from obese to 'non-obese':

$$\Pr(non - obese_{14} = 1 | non - obese_{11} = 0) = f(X) \quad (2)$$

where predictors (X) are shown in Table 7 below.

Transitions

Table 5 shows transitions between normal weight and excess weight between ages 11 and 14, separately by gender. Looking at males, we see that of those classified as normal weight at age 11, 90% remain so at age 14, and 10% had excess weight. Amongst males classified as having excess weight at age 11, three in four remain so at age 14, and one in four were normal weight. For females, we see that of those classified as normal weight at age 11, 85% remain so at age 14, and 15% had become excess weight. Amongst females classified as having excess weight at age 11, four in five remain so at age 14, and one in five were normal weight. So transitions are more positive for males than for females, though differences are not stark.

Table 5. Transition between excess weight and normal weight from age 11 to age 14, by sex

		Males		Females	
		Age 14		Age 14	
		Normal weight	Excess weight	Normal weight	Excess weight
Age 11	Normal weight	2963 89.96	302 10.04	2913 85.63	493 14.37
	Excess weight	458 25.19	1,365 74.81	314 18.78	1,264 81.22

Proportions measured using longitudinal weights at sweep 6. First figure in each cell is sample size; second figure is percentage.

Table 6 shows transitions between obesity and non-obesity between ages 11 and 14, separately by gender. Looking at males, we see that of those who were not obese at age 11, the vast majority – 93% - retain this status at age 14. The figure for females is similar, at just under 92%. Amongst those obese at age 11, 71% of males and 74% of females remain so at age 14.

Table 6. Transition between obese and non-obese status from age 11 to age 14, by sex

		Males		Females	
		Age 14		Age 14	
		Non-obese	Obese	Non-obese	Obese
Age 11	Non-obese	3815 93.39	239 6.61	3793 91.86	330 8.14
	Obese	295 27.84	739 72.16	226 25.61	635 74.39

Proportions measured using longitudinal weights at sweep 6. First figure in each cell is sample size; second figure is percentage.

Modelling transitions

We next estimate a model to understand the factors affecting the likelihood of transiting out of excess weight between ages 11 and 14. Results are shown in Table 7. Factors affecting transitions to normal weight between 11 and 14 include: being male, high level of maternal education, and home ownership. Similar factors are associated with transitioning out of obesity between 11 and 14. However, we see that ethnic minorities, particularly Mixed, Pakistani and Bangladeshi, and Black/Black British are significantly less likely to transit out of obesity by age 14 compared to White; a low level of maternal education is also associated with a lower probability of transiting out of obesity by age 14, relative to high levels of maternal education.

Table 7. Probability of transiting out of excess weight and obesity at age 14, from age 11

Predictive factors		Pr(normal weight at 14|excess weight at 11)		Pr(non-obese at 14|obese at 11)	
		β	S.E.	β	S.E.
		(1)	(2)	(3)	(4)
Sex (ref. female)		0.043***	(0.015)	0.035*	(0.018)
Body hair growth [a] (ref. not grown yet)	barely started to grow	-0.031	(0.020)	-0.032	(0.023)
	definitely started to grow	-0.061***	(0.019)	-0.002	(0.023)
Ethnicity (ref. White)	Mixed	-0.061	(0.039)	-0.082*	(0.046)
	Indian	0.052	(0.054)	0.009	(0.064)
	Pakistani, Bangladeshi	0.013	(0.034)	-0.104**	(0.041)
	Black or Black British	-0.026	(0.035)	-0.086**	(0.041)
	Other ethnic group	-0.086	(0.056)	-0.006	(0.067)
Breakfast not everyday [a]		-0.031	(0.020)	-0.033	(0.024)
Birth weight		-0.000	(0.013)	-0.017	(0.015)
Breastfed 90 days+		0.022	(0.019)	0.024	(0.023)
Mother smoked when CM was 9 months		0.035**	(0.017)	-0.017	(0.021)
Mother's education (ref. no academic qualification)	GCSE D-G w/ voc>=L3+ GCSE D-C or less	-0.045*	(0.025)	-0.059**	(0.029)
	GCSE A-C & A lev w/ voc>=L3	0.007	(0.020)	0.041*	(0.024)
	A lev + voc>= L3 & diplomas in HE	0.011	(0.029)	0.069**	(0.035)
	degree or higher degree	0.049*	(0.029)	0.086**	(0.035)
N. of siblings [a]		0.006	(0.007)	-0.001	(0.008)
Single parent HH [a]		0.025	(0.017)	0.020	(0.021)
Own house [a]		0.057***	(0.017)	0.067***	(0.021)
Country (ref. England)	Wales	-0.004	(0.032)	0.009	(0.038)
	Scotland	-0.020	(0.027)	-0.010	(0.033)
	Northern Ireland	-0.026	(0.033)	0.015	(0.040)
Observations		*3401*		*3401*	

[a] Measured at age 11 (sweep 5).

Conclusion

This study, using unique new data from the UK MCS, presents new evidence on levels of overweight and obesity amongst a nationally representative and contemporaneous sample of adolescents in the UK today. It shows that around 2-in-10 14 year olds is classified as obese, and proportions are very similar across males and females. Just over 6-in-10 are classified as normal weight, and the remainder are overweight – with numbers classified as normal weight (overweight) slightly lower (higher) amongst females than males.

Protective factors for excess weight include breastfeeding for at least 90 days, home ownership and high maternal education; ethnic differences in weight are stark, with

children from Indian, Pakistani and Bangladeshi and Black ethnic backgrounds displaying a higher probability of excess weight status than White children.

Looking at transitions in weight status between the important ages of 11 and 14, coinciding with move to secondary school, more independence, and physical maturation, we see that there is considerable persistence in weight status across ages, though reassuringly, higher likelihoods are observed for transiting out of out of excess weight/obesity, compared to transiting out of normal weight.

Finally, the paper considered predictors of transiting out of excess weight/obesity between ages 11 and 14 and found that being male, home ownership and high levels of maternal education are associated with a higher likelihood of transiting out of excess weight/obesity by age 14; ethnic minorities are less likely to reduce in obesity levels compared to Whites.

When interpreting the transition results, however, the extensive debate around limitations in identifying change with two time points must be considered. Using binary outcomes raises further problems due to the loss of information (Glymour, Weuve, Berkman, Kawachi, & Robins, 2005). Further work to examine these patterns in further detail could include to look at continuous (BMIs) change across all of the sample from ages 3 through 14; or test whether associations differ at particular cut-points.

The paper highlights the importance of overweight and obesity in childhood and adolescence as a major public health concern, and provides important evidence to underpin and reinforce the Government commitment to reducing levels of obesity in childhood.

Appendix: Classification of overweight and obesity in childhood

UK90. The UK 1990 thresholds are based on population reference curves derived from around 30,000 BMI measurements from 11 different sources in England, Scotland and Wales collected between 1978 and 1990.(Timothy J Cole, Freeman, & Preece, 1995) The studies span different ages and between them encompass ages 0 to 23 years. The cut-offs are estimated at the age and sex specific 85th centile for overweight and 95th centile for obese. These specific centile cut-offs are used quite widely in national reference charts and have been criticised for being arbitrary centile points whose diagnostic utility is little understood.(Tim J Cole et al., 2000; SACN & RCPCH, 2010) The often discussed strength of the UK90 being a growth reference curve is the ability to estimate individual's BMI as percentiles and standard deviations, which as we will see, the IOTF method did not offer until recently.(T. Cole & Lobstein, 2012) The UK90

approach focuses on comparisons and standardisation based on a UK population, offering the capacity to monitor obesity levels in the UK. The key limitation of this approach is the lack of continuity with the widely used adult cut-offs.

IOTF. The IOTF thresholds for overweight and obesity are based on reference populations of almost 200,000 measurements across six countries (Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States) collected between 1963 and 1993.(Tim J Cole et al., 2000) The studies span different ages and between them encompass ages 0 to 25 years.(Tim J Cole et al., 2000) The age and sex specific thresholds are based on extrapolating from the widely used adult cut off points of 25 and 30 for overweight and obese respectively.(Tim J Cole et al., 2000) At development they could not be expressed as centiles, however recent developments have updated these to make expressing in centiles possible.(T. Cole & Lobstein, 2012) The key strengths of this approach over other approaches are that it encourages internationally comparable obesity prevalences and the thresholds merge into the adult thresholds at age 18 years increasing compatibility with longitudinal research.

Table A1. Prevalence of underweight from age 3 to 14 for the whole sample and by gender

	Age 3		Age 5		Age 7		Age 11		Age 14	
Total	N	%[a]	N	%[a]	N	%[a]	N	%[a]	N	%[a]
3 thinness	131	0.92	38	0.26	51	0.38	32	0.25	36	0.33
2 thinness	224	1.58	88	0.59	87	0.65	112	0.88	99	0.91
1 thinness	1,028	7.24	555	3.75	674	5.01	673	5.3	600	5.54
Total	*14,195*	*100*	*14,790*	*100*	*13,459*	*100*	*12,702*	*100*	*10825*	*100*
Females	N	%[a]	N	%[a]	N	%[a]	N	%[a]	N	%[a]
3 thinness	69	0.98	19	0.26	27	0.41	21	0.34	20	0.38
2 thinness	125	1.78	39	0.54	44	0.66	76	1.21	43	0.81
1 thinness	519	7.41	242	3.35	324	4.88	348	5.55	264	4.96
Total	*7,007*	*100*	*7,226*	*100*	*6,643*	*100*	*6,266*	*100*	*5326*	*100*
Males	N	%[a]	N	%[a]	N	%[a]	N	%[a]	N	%[a]
3 thinness	62	0.86	19	0.25	24	0.35	11	0.17	16	0.29
2 thinness	99	1.38	49	0.65	43	0.63	36	0.56	56	1.02
1 thinness	509	7.08	313	4.14	350	5.13	325	5.05	336	6.11
Total	*7,188*	*100*	*7,564*	*100*	*6,816*	*100*	*6,436*	*100*	*5499*	*100*

Percentages are not weighted.

[a] Percentages calculated on total (or total females or total males) respondents at each sweep.

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