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Research

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Abstract

Objective To examine the developmental trajectory of obesity in adolescence in relation to sex, ethnicity, and socioeconomic status.

Design Five year longitudinal cohort study of a socioeconomically and ethnically diverse sample of school students aged 11-12 years at baseline.

Setting 36 London schools recruited to the study in 1999 by a stratified random sampling procedure.

Participants 5863 students participated in one or more years.

Main outcome measures Weight, height, and waist circumference measured annually by trained researchers; overweight and obesity defined according to International Obesity Task Force criteria; adiposity and central adiposity indexed by body mass index (BMI) and waist standard deviation scores relative to 1990 British reference values.

Results In school year 7 (age 11-12), the prevalence of overweight and obesity combined was almost 25%, with higher rates in girls (29%) and students from lower socioeconomic backgrounds (31%) and the highest rates in black girls (38%). Prevalence of obesity increased over the five years of the study at the expense of overweight, but no reduction occurred in the proportion of students with BMIs in the healthy range. Waist circumferences were high compared with 1990 norms at age 11 (by 0.79 SD in boys and by 1.15 SD in girls) and increased further over time. Both BMI and waist circumference tracked strongly over the five years.

Conclusions Prevalence of overweight and obesity was high in London school students, with significant socioeconomic and ethnic inequalities. Little evidence was found of new cases of overweight or obesity emerging over adolescence, but few obese or overweight adolescents reduced to a healthy weight. The results indicate that persistent obesity is established before age 11 and highlight the need to target efforts to prevent obesity in the early years.

Introduction

Adolescent obesity is associated with all the long term risks of adult obesity and may carry additional risks for metabolic disorders and poor body image associated with earlier onset.[1][2] Dietz has highlighted the need for research into the factors that contribute to the development and persistence of overweight during adolescence to inform effective prevention.[3] Ethnicity and socioeconomic status are consistently associated with risk of obesity,[4–7] but few studies have systematically compared ethnic groups and socioeconomic status groups in relation to the development of adiposity in adolescence. As part of a five year longitudinal study, this paper examines the developmental trajectory of weight and abdominal adiposity from age 11 to age 16 in relation to socioeconomic status, ethnicity, and sex.

Methods

We randomly selected 36 secondary schools in south London, stratified by area and school type to generate an ethnically and socioeconomically diverse sample. Data collection started in 1999 with students in year 7 (age 11-12) and continued annually to year 11 (age 15-16). All students in the relevant school year were eligible to take part. Students completed questionnaires covering demographic characteristics and health behaviours. We took weight, height, and waist measurements. We calculated body mass index (BMI) and waist standard deviation (SD) scores and established weight status by using the International Obesity Task Force criteria, which identify BMI values for each age.[8] We collected ethnicity data by self report. Students reported their postcodes, which we used to derive an area based measure of socioeconomic deprivation.[9]

Statistical analysis—We examined the prevalence of overweight and obesity in the whole sample and by sex, socioeconomic status, and the three main ethnic subgroups. We modelled variation between individual students in the rate of change of adiposity for absolute BMI and waist circumference and for BMI and waist SD scores.

Results

Across all five years 5863 students participated in the study. After exclusion of students with missing data, the sample for the longitudinal analysis was 5320.

At year 7 (age 11-12) black girls were significantly taller and heavier, and had a higher BMI, than white or Asian girls. Black boys were heaviest and tallest, and Asian boys were shortest. Waist circumferences were highest in black girls and boys (all $P < 0.001$).

Prevalence of overweight and obesity

Between 16.9% and 19.3% of students were classified as overweight and 5.5-6.9% as obese. More girls than boys were overweight or obese in all years (all $P < 0.001$) (table 1). Rates of obesity increased over the five years in boys ($P < 0.001$) and girls ($P = 0.009$), but a corresponding decrease occurred in the rates of overweight. We found no change in the rates of overweight and obese combined, and therefore no

reduction in the proportion classed as "healthy weight." From year 7 to year 11, the number of students who moved from overweight/obese to normal weight (7.6%) was similar to the number who moved from normal weight to overweight/obese (7.0%).

The percentages of girls who were overweight or obese, averaged over the five years, after adjustment for socioeconomic status, were 28.0 for white, 38.2 for black, and 19.8 for Asian girls. Asian boys had the highest rates for boys in all years, but ethnic differences were not significant.

Averaged over the five years and after adjustment for ethnicity, 35.2% of the most deprived girls were overweight or obese compared with 27.8% of other girls. The trend across the other deprivation categories was inconsistent, with high levels of overweight and obesity in the least deprived girls in years 7 and 11. In boys, the most deprived had the highest rates of overweight or obesity, but differences were not significant.

Adiposity trends over time—longitudinal change in adiposity
Table 2 shows the absolute values of BMI and waist circumference by sex and ethnicity for each school year. BMI increased on average by 0.726 (SE 0.015) units per year from year 7 to year 11 (see extra table on bmj.com). Girls' mean BMI was higher than boys' by 1.042 (SE 0.112) units, but the rates of increase did not differ between boys and girls. We found a significant effect of socioeconomic status on BMI but no interactions between socioeconomic status and either sex or school year. Black students had BMI values 0.554 (SE 0.135) higher than white students. We found a significant sex by ethnic group interaction (P < 0.001); black girls had an excess of 0.928 (SE 0.272) BMI units.

We did the same analyses for BMI standard deviation scores to examine the trajectory of relative adiposity compared with 1990. Boys and girls were initially 0.526 (SE 0.019) standard deviations above the 1990 norms, with a slight upward trend over time of 0.024 units per annum (SE 0.004). Black students' BMI standard deviation scores were 0.148 (SE 0.042) higher than those of white students, and Asian students' scores were 0.151 (SE 0.051) lower. BMI standard deviation scores were higher in the more socioeconomically deprived groups (P = 0.007).

Trends in abdominal adiposity
Waist circumferences increased on average by 2.31 (SE 0.09) cm/year from year 7 to year 11; the increase in boys was 0.992 (SE 0.082) cm greater than that in girls. Waist circumferences were significantly higher in lower socioeconomic status groups (P < 0.007). Black girls had waist circumferences 2.138 (SE 0.638) cm larger than white girls (P < 0.001), and Asians had the smallest waists (P < 0.001), but little difference existed between ethnic groups among boys.

Students entered the study with waist standard deviation values higher than the 1990 reference level—boys by 0.798 (SE 0.019); girls by 1.15 (SE 0.03). Over the next four years, girls deviated further to reach 1.44 (SE 0.030) standard deviation units above their 1990 norms by age 15-16, and boys reached 0.926 (SE 0.022). The school year by sex interaction was statistically significant (P < 0.001). Black students' waist standard deviation scores were higher than those of white students by 0.110 (SE 0.037) units, but the annual rate of increase was 0.034 (SE 0.009) less than that of white students. This ethnicity by school year interaction was statistically significant (P < 0.001). We found a trend towards higher waist standard deviation scores with increased deprivation (P = 0.016).

Tracking of adiposity
Year to year correlations of BMI scores were high, at 0.94 for a one year interval between measurements and reducing to 0.90, 0.86, and 0.82 for two, three, and four year intervals. The pattern for tracking of waist circumference was similar, with correlations from 0.86 for a one year measurement interval to 0.70 for a four year interval.

Discussion

Development of adiposity
Rates of overweight and obesity in our cohort were higher for students living in lower socioeconomic status neighbourhoods and for girls from black ethnic groups. Over this four year period, rates of obesity rose by one to two percentage points, but rates of overweight declined by the same amount, so the proportion of students with body sizes in the healthy weight range was unchanged. This pattern is more consistent with increasing adiposity in a vulnerable subgroup than with an overall effect on adiposity.[5] [10] [11]

Table 1 Prevalence of overweight and obesity. Values are percentages (numbers)

	Year 7	Year 8	Year 9	Year 10	Year 11
Whole sample					
Healthy weight	75.9 (3054)	74.7 (3103)	73.8 (2974)	76.0 (3016)	76.3 (2672)
Overweight	18.6 (750)	19.3 (802)	19.3 (778)	17.0 (676)	16.9 (592)
Obese	5.5 (220)	6.0 (248)	6.9 (276)	7.0 (277)	6.8 (237)
Girls					
Healthy weight	70.2 (1138)	69.9 (1199)	69.6 (1179)	72.2 (1216)	71.3 (1053)
Overweight	23.1 (374)	23.0 (395)	22.4 (380)	19.5 (329)	20.4 (301)
Obese	6.7 (109)	7.1 (121)	8.0 (135)	8.3 (140)	8.3 (122)
Boys					
Healthy weight	79.8 (1916)	78.1 (1904)	76.9 (1795)	78.8 (1800)	79.9 (1619)
Overweight	15.6 (376)	16.7 (407)	17.1 (398)	15.2 (347)	14.4 (291)
Obese	4.6 (111)	5.2 (127)	6.0 (141)	6.0 (137)	5.7 (115)

Table 2 Mean (SD) body mass index and waist circumference by sex, ethnicity, and year of study

	Year 7	Year 8	Year 9	Year 10	Year 11
Body mass index					
Girls:					
White	19.7 (3.5)	20.5 (3.6)	21.4 (3.7)	22.0 (3.9)	22.6 (3.8)
Black and mixed black	21.2 (4.1)	22.0 (4.1)	22.7 (4.3)	23.4 (4.5)	24.1 (4.6)
Asian and mixed Asian	19.3 (3.5)	19.7 (3.2)	20.5 (3.4)	21.1 (3.6)	21.4 (3.3)
Boys:					
White	18.9 (3.1)	19.7 (3.3)	20.5 (3.3)	21.2 (3.5)	21.8 (3.5)
Black and mixed black	19.4 (3.8)	20.1 (3.8)	20.8 (3.8)	21.6 (3.9)	22.2 (3.9)
Asian and mixed Asian	19.0 (3.3)	19.8 (3.8)	20.7 (4.0)	21.2 (3.9)	21.9 (4.2)
Waist circumference					
Girls:					
White	67.1 (7.3)	68.8 (7.4)	71.2 (7.8)	73.1 (8.2)	74.8 (8.4)
Black and mixed black	70.6 (8.1)	72.1 (8.1)	74.1 (8.6)	75.7 (9.1)	77.3 (8.5)
Asian and mixed Asian	65.8 (6.9)	67.2 (6.8)	69.0 (7.1)	70.8 (7.2)	71.6 (9.9)
Boys:					
White	67.4 (7.4)	70.2 (7.8)	73.3 (8.0)	76.3 (8.3)	78.8 (8.4)
Black and mixed black	68.4 (7.8)	70.8 (7.8)	73.4 (7.9)	76.0 (8.4)	78.5 (8.5)
Asian and mixed Asian	68.1 (8.5)	70.8 (8.8)	74.0 (9.3)	76.5 (9.1)	79.1 (9.9)

Adiposity tracked strongly over time, indicating that children who are fatter than average at age 11 are likely still to be fatter at age 15. In our sample, very few students who were obese in year 7 later changed to normal weight status. Obesity in early adolescence is a clear indication of persistent obesity. These findings indicate that the major development of early adiposity is fully established by age 11. Thus the high risk period for onset of persistent obesity may be in the pre-adolescent years, which has important implications for targeting preventive efforts. On the basis of BMI standard deviation scores, a small but significant increase in relative adiposity seemed to occur over time as the cohort matured. The high level of tracking for waist circumference observed in our data indicates that risks for metabolic syndrome are developing very early in life.

Socioeconomic differences in adiposity

We found strong evidence of ethnic differences—black girls had almost double the prevalence of overweight and obesity of white girls, across all five years. The ethnic difference was restricted to girls, a phenomenon that has been noted in other studies, and persists into adult life, but is poorly understood.

Differences with socioeconomic status were less clear cut. Students in the lowest fifth had higher rates of overweight and obesity, and this pattern was maintained over the five years and seen in both sexes. Differences were not systematically graded across levels of socioeconomic status, and rates of overweight and obesity were also high in the least deprived girls in years 7 and 11. More work is needed to understand when in the developmental process differences in adiposity by socioeconomic status emerge.

Limitations

Several factors limit generalisation of these results. The sample was restricted to an urban British setting. However, it had the advantage of a large sample size and strong representation from ethnic minorities. A degree of participation bias occurred, whereby students seen on fewer occasions had slightly larger waists and BMIs. Thus, the prevalence of obesity and overweight may be very slightly underestimated. The broad classification of ethnicity means that conclusions cannot be drawn about variation within ethnic subgroups.

Conclusion

The results of this study highlight the need to examine the trajectory of adiposity earlier in childhood, because the high risk period may be getting earlier.

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What is already known on this topic

Adolescence is assumed to be a critical period for the development of obesity, but no UK data on developmental trends in adolescence exist

Adults show strong demographic patterning of obesity (higher prevalence in lower socioeconomic groups and black women), but whether this emerges in adolescence is unknown

Abdominal adiposity, indexed by waist circumference, rose dramatically in children and adolescents in the 1990s and may be continuing to rise

What this study adds

Few incident cases of overweight emerged during adolescence, suggesting that pre-adolescence may be the higher risk period

Obesity was most prevalent in lower socioeconomic groups; no evidence exists for increasing socioeconomic inequalities over the adolescent years

Young black women have strikingly high rates of obesity, which are not matched in young black men

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Endpiece

Pain

If you are distressed by anything external, the pain is not due to the thing itself, but to your estimate of it; and this you have the power to revoke at any moment.

Marcus Aurelius Antoninus,
Roman emperor, AD 121-180

Luke Cascarini, senior house officer, maxillofacial surgery, Queen Victoria Hospital, East Grinstead, West Sussex