

Ethnic and gender differences in body fat in British schoolchildren as measured by DXA

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Background: There are known to be ethnic differences in body composition in adults which are related to ethnic differences in adult disease.

Objectives: To evaluate gender and ethnic differences in percentage body fat in British schoolchildren and to compare these differences with classification of obesity using body mass index (BMI) criteria.

Design: A cross-sectional study of 1251 healthy children and adolescents aged 5–18 years from white, South Asian and African-Caribbean ethnic groups. Percentage body fat was determined by dual x ray absorptiometry and the subjects classified using BMI criteria for overweight and obesity.

Results: Significant gender differences in percentage body fat were seen, with girls having higher values from the age of 5 years. Girls had 3.8% higher percentage body fat at 5 years of age increasing to 12.9% at 18 years of age. Significant ethnic differences were found, with South Asian girls and boys having the highest percentage body fat from 5 and 7 years of age, respectively. These differences increased with age, being most significant in the teenage years. Although South Asian girls and boys were over-represented in the group containing children with more than 25% body fat ($p < 0.0001$, χ^2 test), African-Caribbean subjects were more likely to be classified as obese using BMI criteria.

Conclusions: There are clear gender and ethnic differences in percentage body fat in British schoolchildren which may relate to known differences in the risk of type 2 diabetes in adolescence and adulthood. BMI criteria for defining overweight and obesity do not accurately identify ethnic differences in body fat.

It is well known that in adulthood there are ethnic differences in the prevalence of certain chronic diseases, particularly type 2 diabetes, which are related to differences in body composition. A study conducted in West London¹ in the early 1990s of 4000 men and women identified 19% of the South Asian subjects as having diabetes compared to 4% of the European adults. These differences were related to higher insulin levels and increased waist–hip ratios as an index of central adiposity in the South Asian group. Other studies from India² and the USA³ have demonstrated an increased proportion of central body fat in South Asian subjects despite a normal body mass index (BMI).

A recent study of 5689 children and young adults aged 2–20 years⁴ from the 1999 Health Survey for England examined ethnic differences in the prevalence of overweight and obesity as defined by International Obesity Task Force (IOTF) criteria for BMI. Indian and Pakistani boys and African-Caribbean girls had a higher prevalence of being overweight compared to the general population, with the prevalence of obesity in the African-Caribbean girls being twice that seen in the general population. However, no assessment of body composition was used in that study so it is not known whether a higher BMI represented a higher proportion of body fat or was related to other components of body composition such as lean body or bone mass.

We have previously demonstrated ethnic differences in percentage body fat between South Asian and white European adolescents which are associated with evidence of increased insulin resistance in the South Asian subjects.⁵ It is not currently known at what age these ethnic differences in body composition may be seen. The aims of this study were to identify at what age differences in body fat can be seen in British schoolchildren from three ethnic groups and how these relate to known differences in BMI.

METHODS

Over a 4-year period from 1998 to 2002, 1251 children aged between 5 and 18 years were recruited in two cities in the UK, Birmingham in the West Midlands and Middlesbrough in the North East. The children were recruited as part of a study to produce normative data for bone density in British children and were recruited from schools and colleges who agreed to participate in the study after being approached by a research nurse. Ethical approval was obtained from the local research ethics committees in South Birmingham and Middlesbrough, with informed written consent obtained from parents of children under 16 years of age. Children were recruited from white (W), South Asian (SA) and African-Caribbean (AC) ethnic groups with both parents belonging to the same ethnic group. Children with chronic illness other than asthma were excluded. However, children with asthma receiving oral corticosteroids were also excluded. The height of each child was measured using a Leicester height stadiometer to the nearest 0.1 cm and each child was weighed in light indoor clothing using hospital balance scales to the nearest 0.1 kg. Each child underwent a whole body scan using dual-energy x ray absorptiometry (DXA) on a GE Lunar DPX-L scanner with the two scanners in the different centres being cross calibrated to ensure consistent values. From the whole body scans we were able to obtain a measurement of fat mass expressed as a percentage of body weight. Height, weight and BMI were converted into standard deviation scores (SDS) by comparison with UK reference data.^{6,7} The proportions of children who were overweight and obese were defined using the IOTF standards of BMI.⁸

Abbreviations: AC, African-Caribbean; BMI, body mass index; DXA, dual-energy x ray absorptiometry; IOTF, International Obesity Task Force; SA, South Asian; SDS, standard deviation score; W, white

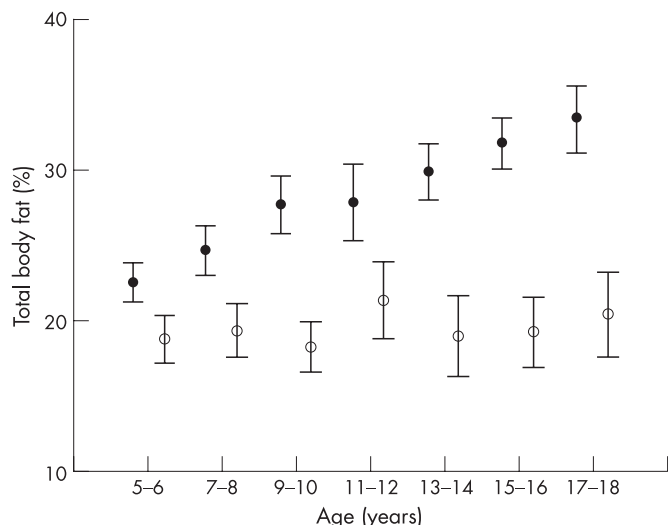


Figure 1 Gender differences in percentage body fat (closed circles: girls, open circles: boys) Mean \pm 95% confidence intervals.

The data were analysed using SPSS version 11.0 (SPSS, Chicago, IL). Ethnic and gender differences were evaluated using analysis of variance, adjusting for body weight where appropriate. Differences in proportions were evaluated using χ^2 test. Results are presented as means and standard deviations unless otherwise stated. A level of $p < 0.05$ was used to denote statistical significance.

RESULTS

The characteristics of the children are shown in table 1 which indicates that approximately twice as many white children were recruited compared to the two other ethnic groups. Initial analysis identified significant differences in body size between the three ethnic groups. Overall, the African-Caribbean children were significantly taller and heavier than the South Asian and white children (mean height SDS: AC = 0.54 (0.06), SA = -0.15 (0.06), W = 0.30 (0.04); mean weight SDS: AC = 0.85 (0.08), SA = 0.12 (0.08), W = 0.41 (0.04)). In addition, the African-Caribbean and white children were

significantly taller and heavier than the 1990 UK growth standards, while the South Asian children were significantly shorter. All three groups had higher BMIs than the 1990 UK standards, but this increase was only significantly different from zero for African-Caribbean children (BMI SDS: AC = 0.75 (0.08), SA = 0.024 (0.08), W = 0.37 (0.04)). Using IOTF standards, 24.6% of the girls and 22% of the boys were overweight and 7.5% of both genders were obese. Significant gender differences in percentage body fat were seen in relation to age (fig 1). Clear differences were seen as early as 5 years of age, with girls having 3.8% higher percentage body fat compared to boys (girls 22.6%, boys 18.8%; $p < 0.001$). These differences increased with age, with the girls at 18 years of age having 12.9% higher percentage body fat than the boys (girls 33.4%, boys 20.5%; $p < 0.001$). These gender differences were seen even when adjusted by body weight in a linear regression model.

Differences in percentage body fat in relation to ethnic group are shown in fig 2A and B after adjustment for body weight. At the age of 5 years, the South Asian girls had the highest percentage body fat, which was significantly different from that of the African-Caribbean girls ($p < 0.001$), and this trend continued with increasing age, although between 11 and 12 years of age the white girls had the highest values. Between 15 and 18 years of age there are striking differences in percentage body fat, with the South Asian girls having values significantly higher than the two other ethnic groups. A similar pattern was seen in the boys, with the South Asian boys having significantly higher values than the African-Caribbean boys from 7 to 10 years of age, and by 15–16 years of age they had significantly higher values than the two other ethnic groups. The African-Caribbean and white, but not the South Asian, boys showed a reduction in percentage body fat after 12 years of age. Table 2 indicates the distribution of percentage body fat between the ethnic groups and shows that South Asian boys and girls were over-represented in the group with more than 25% body fat, which was highly significant in a χ^2 test ($p < 0.001$). Table 3 shows the distribution of the ethnic groups using the IOTF classification for overweight and obesity. Here it is apparent that the African-Caribbean boys and girls are over-represented in the obesity group, being significant for the girls in a χ^2 test (girls, $p < 0.005$; boys $p = 0.01$).

Table 1 Subject demographics represented as standard deviation scores (SDS) by gender, ethnic group and age

Age group (years)	South Asian				African-Caribbean				White			
	n	Height (cm)	Weight (kg)	BMI (kg/m ²)	n	Height (cm)	Weight (kg)	BMI (kg/m ²)	n	Height (cm)	Weight (kg)	BMI (kg/m ²)
Girls												
5-6	24	0.16 (0.91)	0.04 (1.20)	-0.10 (1.14)	22	0.80 (0.79)*	0.90 (0.93)*	0.61 (1.03)†	58	0.10 (1.00)	0.24 (0.86)	0.23 (0.82)
7-8	25	0.19 (1.21)	0.42 (1.78)	0.47 (1.78)	34	0.66 (1.13)	0.51 (1.10)	0.27 (1.12)	72	0.23 (1.01)	0.36 (1.01)	0.34 (1.00)
9-10	26	-0.7 (1.03)‡	0.02 (1.29)	0.06 (1.39)	26	0.56 (1.20)	0.86 (1.28)†	0.80 (1.43)†	57	0.41 (0.85)	0.48 (0.90)	0.36 (1.03)
11-12	17	0.27 (1.03)	-0.04 (1.37)‡	-0.45 (1.6)	16	1.00 (1.14)†	1.17 (1.38)	0.85 (1.33)	43	0.48 (1.00)	0.69 (1.12)	0.54 (1.27)
13-14	22	-0.27 (1.18)	0.22 (1.15)	0.45 (1.18)	17	0.39 (0.88)†	0.87 (1.11)	0.83 (1.13)	50	0.14 (0.96)	0.32 (0.97)	0.36 (1.02)
15-16	33	-0.88 (1.04)‡	-0.47 (1.51)‡	0.08 (1.39)	12	0.28 (0.93)	0.69 (1.62)	0.60 (1.78)	66	0.53 (0.94)	0.46 (1.05)	0.33 (0.99)
17-18	24	-0.62 (1.17)‡	0.09 (1.28)	0.53 (1.09)	10	0.34 (1.05)	1.15 (1.05)†	1.08 (1.16)	22	0.41 (1.33)	0.43 (1.04)	0.36 (0.89)
Boys												
5-6	25	-0.40 (1.08)‡	-0.45 (1.41)§	-0.28 (1.38)§	18	0.81 (0.99)	1.35 (1.55)	1.21 (1.59)	48	0.33 (0.75)	0.50 (0.86)	0.40 (1.06)
7-8	27	0.07 (1.19)	0.38 (1.46)	0.50 (1.43)	26	0.46 (0.87)	0.99 (0.87)	1.03 (1.03)	56	0.08 (0.95)	0.26 (1.15)¶	0.28 (1.22)*
9-10	26	0.28 (1.12)	0.25 (1.14)	0.17 (1.20)	23	0.78 (0.85)	0.83 (1.03)	0.63 (1.23)	56	0.20 (0.97)¶	0.17 (0.98)¶	0.09 (1.04)
11-12	18	-0.28 (1.08)	-0.15 (1.38)	-0.05 (1.40)	17	0.19 (1.21)	0.93 (1.48)	1.15 (1.36)†	33	**0.46 (0.78)	0.65 (0.78)**	0.55 (0.88)
13-14	18	-0.13 (1.10)	0.32 (1.40)	0.46 (1.46)	11	0.17 (1.27)	0.38 (1.31)	0.42 (1.04)	41	0.23 (1.19)	0.23 (1.12)	0.11 (1.08)
15-16	29	0.04 (0.78)	0.49 (1.34)	0.54 (1.53)	10	-0.13 (0.73)	-0.14 (0.92)	-0.05 (1.05)	41	*0.51 (0.93)	0.78 (1.14)¶	0.64 (1.19)
17-18	25	-0.27 (0.93)	0.42 (1.36)	0.66 (1.32)	11	0.31 (1.08)	0.58 (0.91)	0.60 (0.60)	11	0.00 (1.18)	0.79 (0.93)	0.93 (1.04)

*AC significantly different from SA and W ($p < 0.05$); †AC significantly different from SA ($p < 0.05$); ‡SA significantly different from AC and W ($p < 0.05$); §all significantly different; ¶W significantly different from AC; **W significantly different from SA. AC, African-Caribbean; SA, South Asian; W, white.

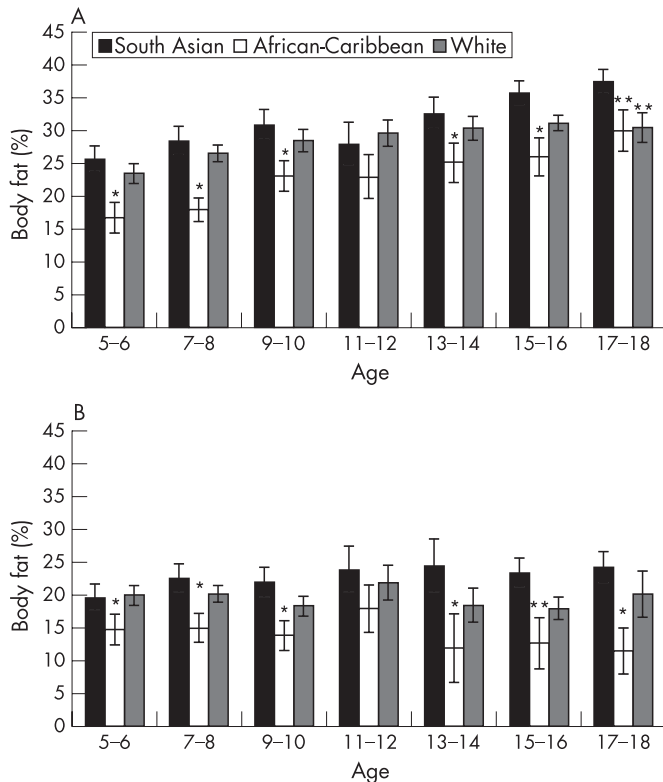


Figure 2 Ethnic differences in percentage body fat, adjusted for body weight in (A) girls and (B) boys. Mean \pm 95% confidence intervals. *AC significantly different from SA and W; **SA significantly different from AC and W. AC, African-Caribbean; SA, South Asian; W, white.

DISCUSSION

This study of body composition in British schoolchildren has shown that ethnic and gender differences in percentage body fat can be seen as early as 5 years of age and become more evident with increasing age with striking differences in percentage body fat being seen in the teenage years. The largest differences were seen between the South Asian and African-Caribbean children, and South Asian teenage girls had the highest values for percentage body fat. It is apparent that classification of subjects as overweight or obese by IOTF criteria does not recognise these ethnic differences in percentage body fat. While a higher proportion of African-Caribbean children are classified as obese, the South Asian children have the highest percentage body fat. Our study has also demonstrated that the prevalence of obesity in our cohort at 7.5% is higher than the previously reported prevalence of 6% in UK children.⁴

Gender differences in body fat in prepubertal children have previously been recognised. A study in the south west of England using skinfold thicknesses showed that girls at the age of 5 years carried 26% more subcutaneous fat than boys.⁹ Prepubertal children in New York studied using DXA and skinfold thicknesses also demonstrated clear gender

differences, with the girls having greater body fat.¹⁰ Ethnic differences in body composition using DXA have been examined in other populations of children and young adults. A study of 358 prepubertal children aged 5–12 years from New York used DXA to examine differences between Caucasian, African-American and Asian (Chinese and Korean) subjects.¹⁰ The Asian children had lower values for extremity body fat in comparison with the Caucasian subjects. Two studies from Houston, Texas^{11, 12} examined body composition in European-American, African-American and Mexican-American (Hispanic) girls and boys aged 3–18 years. Both studies identified the Hispanic subjects as having higher values for fat mass and percentage body fat after adjustment for body size differences. Our study is the first UK study to examine ethnic differences using DXA.

It is now well established that Asian adult subjects have higher levels of body fat than European subjects with comparable BMI values, which has led to a revision of WHO recommendations for appropriate BMI cut-off levels in Asian populations.¹³ Our study has demonstrated that similar differences in body fat are present in South Asian children at comparable levels of body weight or BMI. It is of note that the South Asian boys in our study did not demonstrate a fall in percentage body fat in the teenage years as was seen in the white and African-Caribbean boys and has also been demonstrated as a normal physiological phenomenon using bioimpedance in a large cohort of Caucasian children in the UK.¹⁴ Although our study did demonstrate higher BMI values in the African-Caribbean subjects as seen in the Health Survey for England,⁴ this was not reflected in higher values for body fat. Thus BMI does not accurately indicate percentage body fat and the use of similar BMI criteria for different ethnic groups may lead to errors in identifying obese children. This will be important if BMI criteria are used to identify those children who should be referred for specialist obesity services. The limitations of BMI as a measure of the fatness of an individual has been mentioned in a recent review paper.¹⁵ A similar discrepancy between BMI and percentage body fat across ethnic groups has been shown in a study of black and white children and adolescents from Cincinnati.¹⁶

If the data are reanalysed with adjustment for height rather than weight, the differences in body composition for the girls from the age of 9 years are no longer significant and may represent the fact that the unadjusted differences are due to body weight and not stature. In the boys significant differences in the younger age groups disappear but remain significant between 13 and 18 years of age. These discrepancies between apparent ethnic differences in body composition after adjustment for height or weight may be explained by environmental and genetic interactions on nutrition, linear growth and proportion of body fat. Further work investigating longitudinal changes are required to provide more insight.

Our study has demonstrated ethnic differences in percentage body fat amongst contemporary UK children that are apparent at an early age prior to the onset of puberty and which become more marked with puberty. We have shown these variations to

Table 2 Ethnic and gender differences in the distribution of proportions of body fat

% Fat group	South Asian		African-Caribbean		White	
	Girls	Boys	Girls	Boys	Girls	Boys
Less than 15%	8 (4.7%)	52 (31.5%)	31 (22.8%)	67 (58.8%)	13 (3.6%)	115 (40.5%)
15–25%	51 (29.8%)	58 (35.2%)	48 (35.3%)	25 (21.9%)	134 (37.1%)	113 (38.9%)
More than 25%	112 (65.5%)	55 (33.3%)	57 (41.9%)	22 (19.3%)	214 (59.3%)	56 (23.6%)

Table 3 Ethnic and gender differences in the distribution of normal, overweight or obese children as classified by BMI⁸

BMI classification	South Asian		African-Caribbean		White	
	Girls	Boys	Girls	Boys	Girls	Boys
Normal	127 (74.3%)	124 (73.8%)	91 (66.4%)	84 (72.4%)	294 (79.9%)	236 (82.5%)
Overweight	32 (18.7%)	34 (20.2%)	29 (21.2%)	17 (4.7%)	55 (14.9%)	32 (11.2%)
Obese	12 (7.0%)	10 (6.0%)	17 (12.4%)	15 (12.9%)	19 (5.2%)	18 (6.3%)

What is already known on this topic

- Ethnic differences in body composition in adults are related to differences in the prevalence of type 2 diabetes.
- African-Caribbean girls have the highest prevalence of obesity amongst UK children.

What this study adds

- Ethnic differences in percentage body fat can be seen from the age of 5 years.
- Body mass index criteria for obesity do not identify these ethnic differences in percentage body fat.

be related to ethnic differences in insulin sensitivity between South Asian and white adolescents which maybe associated with the risk of developing type 2 diabetes in childhood or adulthood.⁵ It is currently recognised that in the UK the relative risk of developing type 2 diabetes in childhood is fourteen times greater in South Asian than in white European children.¹⁷ Those factors, genetic and environmental, that lead to these differences in body composition at a young age need to be identified and should be the focus of future research.

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CONTRIBUTIONS

NJS designed the study and was responsible for drafting the manuscript, NJC undertook the data analysis and produced the tables and figures, and MSK and JNF were responsible for the recruitment of children and data collection in Middlesborough and approved the drafted manuscript.

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Competing interests: None.

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