Birth weight and body fat distribution in adolescent girls

M Barker, S Robinson, C Osmond, D J P Barker

Abstract
Objective—To examine the association between birth weight and body fat distribution in a group of adolescent girls.

Design—A total of 216 white girls who were born in Southampton had their heights, weights, waist and hip circumferences, and skinfold thicknesses measured when they were aged between 14 and 16 years.

Results—The girls who were smallest at birth, but who were fattest at time of measurement were the most centrally obese. In girls whose body mass index was above the median (21 kg/m²), the subscapular to triceps skinfold ratio rose by 9% for every kilogram decrease in birth weight. Among overweight girls, with a body mass index over 25, the ratio rose by 27% for every kilogram decrease in birth weight.

Conclusion—In adolescent girls, the tendency to store fat on the trunk rather than the limbs, seems to be programmed by growth in fetal life, and is most evident in those who are overweight.

(Keywords: birth weight; adolescence; body fat distribution)

Low weight at birth is associated with the development of non-insulin dependent diabetes and the insulin resistance syndrome in adult life. Central obesity is a component of this syndrome. This is one of the observations that has led to the hypothesis that non-insulin dependent diabetes and cardiovascular disease are ‘programmed’ by events in fetal life that lead to persisting changes in the body’s structure and metabolic function.

A number of studies suggest that low birth weight is associated with a central pattern of fat distribution. Increased central fat deposition, indicated by a high ratio of subscapular to triceps skinfolds has been found in 7–12 year old children in the USA who were born small, and also in young adult Mexican-Americans. Higher waist circumference and higher waist to hip ratio have both been associated with low birth weight in adults. These findings suggest that impaired fetal growth leads to increased deposition of fat on the trunk in adult life. A recent case-control study of adolescents in the UK produced findings inconsistent with this hypothesis. There were no differences in the body fat distribution of low birthweight adolescent girls and boys and normal birthweight adolescent controls. Differences in study design make it difficult to
Table 1  Characteristics of the girls (n=216)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>15.6 (0.4)</td>
<td>14.7–16.6</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>162.6 (6.1)</td>
<td>146.0–179.1</td>
</tr>
<tr>
<td>Waist (cm)</td>
<td>68.9 (6.4)</td>
<td>57.0–91.9</td>
</tr>
<tr>
<td>Hip (cm)</td>
<td>95.3 (6.4)</td>
<td>77.0–118.2</td>
</tr>
<tr>
<td>Waist to hip ratio</td>
<td>0.72 (0.04)</td>
<td>0.61–0.86</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>21.5 (2.8)</td>
<td>15.7–30.0</td>
</tr>
<tr>
<td>Triceps skinfold (mm)</td>
<td>15.7 (4.8)</td>
<td>5.8–28.0</td>
</tr>
<tr>
<td>Subscapular skinfold (mm)</td>
<td>12.2 (5.0)</td>
<td>5.9–39.3</td>
</tr>
<tr>
<td>Subscapular to triceps ratio</td>
<td>0.78 (0.19)</td>
<td>0.46–1.60</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>3295 (509)</td>
<td>1220–5180</td>
</tr>
<tr>
<td>Gestation at birth (days)</td>
<td>282 (13)</td>
<td>225–309</td>
</tr>
</tbody>
</table>

Table 2  Mean (geometric) subscapular to triceps ratio by birth weight in girls above and below the median body mass index (numbers of girls in parentheses)

<table>
<thead>
<tr>
<th>Birth weight (g)</th>
<th>≤ 21</th>
<th>&gt; 21</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 3000</td>
<td>0.78 (31)</td>
<td>0.80 (24)</td>
<td>0.79 (55)</td>
</tr>
<tr>
<td>3001–3500</td>
<td>0.73 (44)</td>
<td>0.78 (49)</td>
<td>0.76 (93)</td>
</tr>
<tr>
<td>&gt; 3500</td>
<td>0.75 (33)</td>
<td>0.74 (35)</td>
<td>0.75 (68)</td>
</tr>
<tr>
<td>Total</td>
<td>0.75 (108)</td>
<td>0.78 (108)</td>
<td>0.76 (216)</td>
</tr>
</tbody>
</table>

The mean of the three skinfold measurements taken at each site was calculated and used in the analysis. The subscapular to triceps skinfold ratio was calculated as an index of truncal to peripheral adiposity after Haffner et al. The distributions of the skinfold values were skewed, and were therefore log transformed before analysis. Variables relating to current and early life factors were entered into a multiple regression analysis. Social class was treated as a dichotomous variable, manual versus non-manual households, in tests comparing means, and as a continuous variable in regression analyses.

Results

Age and unadjusted anthropometric details for the 216 girls are given in table 1. There were 98 girls from manual (IIIm, IV, and V) households, and 99 from non-manual (I, II, and IIIm) households. Girls from manual households tended to be shorter and heavier than girls from non-manual households.

As expected, the triceps and subscapular skinfolds, the subscapular to triceps skinfold ratio and the waist to hip ratio were all positively related to body mass index, though the association with skinfold ratio was not statistically significant. Body mass index and skinfold thicknesses fell with increasing age, and values were therefore adjusted to 15.0 years in all subsequent analyses.

Birth weight was positively associated with body mass index (p=0.08). After adjusting for body mass index, birth weight was negatively associated with both subscapular skinfold thickness (p=0.02), and the subscapular to triceps ratio (p=0.05). It was not associated with triceps skinfold thickness. Subscapular skinfold thickness increased by 7% for every kilogram decrease in birth weight (95% confidence interval (CI) 1% to 13%), while the ratio increased by 6% per kilogram decrease in birth weight (95% CI 0% to 12%). These associations were independent of the girl's social class.

Table 2 shows the skinfold ratio by birth weight among girls below and above the median body mass (21 kg/m²). The association between birth weight and the skinfold ratio was strong in girls with body mass indices above the median, among whom there was an 9% increase in the skinfold ratio for every kilogram decrease in birth weight (p=0.02; 95% CI 1% to 16%). At body mass indices over 25, conventionally described as 'overweight', this pattern was even more marked. The skinfold ratio increased by 27% for every kilogram decrease in birth weight (p= 0.03, 95% CI 3% to 56%). The three girls who had body mass indices over 25 and birth weights below 3 kg had a mean skinfold ratio of 1.25.

There were no associations between gestational age at birth and the girls' anthropometry, even after allowing for body mass index. Inclusion of gestational age in the
Birth weight was positively related to body mass index. After allowing for this, we found that low birth weight was associated with a tendency to store fat centrally, measured by an increased subscapular skinfold thickness and a higher ratio of subscapular to triceps skinfold thicknesses. These relationships were independent of the girls’ gestational age at birth and current social class. They confirm findings from two previous studies of children and young adults. The girls in our study were at varying stages of the adolescent growth spurt, when body fat distribution changes. This might weaken associations between birth weight and central fat deposition. In our study, low birth weight was not associated with an increased waist to hip ratio. Subscapular to triceps skinfold ratio and waist to hip ratio reflect different aspects of body fat distribution, and the association between low birth weight and high waist to hip ratio has only been described in older adults.

Central fat deposition is associated with insulin resistance and an increased risk of non-insulin dependent diabetes in women, independently of overall level of body fatness. Our data show that teenage girls in Britain who were small at birth but who are fatter at age 14 to 16 are already depositing fat centrally. Adolescence has been identified as a critical period for the development of obesity. A higher than average body mass in adolescence may therefore entrain a tendency to deposit fat centrally, which is initiated by undernutrition in fetal life. Because of its association with insulin resistance, the development of central obesity in young women may have implications not only for their long term health, but for the intrauterine development of their offspring. It may be important for girls who were small at birth to avoid becoming overweight.

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