Tracking of Body Size from Birth to Late Adolescence: Contributions of Birth Length, Birth Weight, Duration of Gestation, Parents’ Body Size, and Twinship

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Birth weight has correlated positively with adult body mass index (BMI), but rarely have birth length, duration of gestation, or parents’ body size been taken into account. The authors examined tracking of birth length and weight, adjusted for gestational age, to late adolescence, with special reference to parents’ height and BMI. Longitudinal information from a nationally representative sample of Finnish twin adolescents (birth cohorts 1975–1979) and their parents was collected via questionnaires mailed when the twins were aged 16 years (n = 4,376; 2,062 males, 2,314 females) and 18 years (n = 3,917; 1,742 males, 2,175 females). The twins showed significant tracking of body size from birth to late adolescence, which was greatly influenced by their parents’ body size. Height in adolescence was predicted by length and weight at birth and by parents’ height, whereas BMI was predicted by birth weight and parents’ BMI. An especially high risk for overweight was found for subjects of average length but a high weight at birth. These findings suggest that the intrauterine period has enduring effects on later body size but leave unresolved whether these effects are genetic or environmental. Am J Epidemiol 2001;154:21–9.

High birth weight has been associated with overweight and obesity in children (1–12), adolescents (12–14), and adults (12, 14–20). Likewise, infants of high weight relative to length at birth (e.g., ponderal index (kg/m3)) have a higher degree of overweight or obesity in childhood (21) and in adulthood (15, 16). We found only two studies reporting no relation between heaviness at birth and body size in childhood (22) or adulthood (23); in these surveys, the lack of significance could have been due to relatively small sample sizes of non-population-based cohorts. Furthermore, birth weight consistently has been shown to correlate positively with height in children (3, 8) and in adults (12, 20, 24), as is the case with length at birth and height in adulthood (17, 24). However, birth length has shown no association with adult body mass index (BMI (kg/m2)) (17). Consistent with these findings, infants small for gestational age or of very low birth weight also have been shown to be shorter and lighter in adulthood than those in the normal population (25–27).

Only 10 (1, 3, 8, 10, 16, 17, 20, 24, 26, 27) of the 27 above-mentioned studies have adjusted birth weight or length for duration of gestation; without that information, it cannot be determined whether greater weight or length at birth is caused by long gestation or whether the infants are truly large for their gestational age. Judging from a study of over 400,000 US children (8), size for gestational age matters: smallness for gestational age, rather than smallness due to prematurity, was an indicator for shortness and lightness in early childhood. Although a catch-up in size among infants small for gestational age and a “lag-down” in size among infants large for gestational age do occur during the first 6–12 months (1, 3), small subjects generally seem to remain smaller, and large subjects larger, throughout their lifespan.

In addition, few studies of the tracking of body size from birth to adulthood have allowed for the height and weight of both parents. It is known that tall parents tend to produce tall children and short parents short children (28–30), and, not with the same consistency, that overweight parents tend to produce heavier newborns (31). Interestingly, the mother’s and father’s own birth weights have been reported to have significance for the infant’s birth size (28, 32). All of this information suggests that body size has a strong genetic component, evidenced also by genetic epidemiologic studies (33–36). However, body build is “plastic” and is shaped by its environment throughout growth (37) and the entire lifespan. For example, a study of human ovum donation (38) has shown that an affluent intrauterine environment provided by a heavy recipient mother produces heavier babies,
regardless of the genetic contribution of the donor mother. Maternal weight gain (39–41) and diabetes (41) during pregnancy also have well-known additive effects on birth weight. Conversely, a mother’s smoking (40, 42, 43) and poor parental socioeconomic status (44, 45) reduce newborn size.

Cross-sectional studies have revealed that the risk for childhood and adult obesity is higher if parents are more obese (46, 47). Longitudinally, the probability of a child becoming an obese adult given his or her parents’ obesity has rarely been studied (48, 49). In the 1958 British birth cohort, the tracking of BMI from childhood (age 7 years) to adulthood (age 33 years) was shown to be strongest for subjects with two obese parents (48). For US children born in 1965–1971, the risk for adult obesity predicted at age 1–10 years increased by an increasing number of obese parents, regardless of whether the children themselves were obese; after age 10 years, the obesity status of the child became a more important predictor of adult obesity (49). These two studies did not include information on birth weight, but research on the tracking of birth weight in childhood has shown that high maternal (2, 5–7, 9, 21) or paternal (2, 5–7, 9) BMI increases a child’s risk of becoming obese. In only one study (the Nurses’ Health Study (19)) was the relation between birth weight and adult relative weight in females adjusted for maternal, although not paternal, body habitus. In that study, a mother’s overweight increased her daughter’s risk for adult overweight in all birth weight groups.

Parental height has not been associated with children’s obesity, but the magnitude of catch-up growth in children small for gestational age has been found to be larger if parents are taller (30, 50, 51).

Tracking of body size from birth to adulthood given both parents’ characteristics has not often been studied, and only rarely have both birth weight and length, adjusted for duration of gestation, been analyzed jointly. The purpose of this study was to determine 1) how birth length and weight, adjusted for gestational age, track from birth to late adolescence and 2) whether parental height and BMI contribute to this tracking.

MATERIALS AND METHODS

Subject population

In the FinnTwin16 study (52), all Finnish twins born in 1975–1979 and their siblings and parents were sent questionnaires within 2 months of the twins’ 16th birthdays (study years 1991–1995). Of 3,065 families in which both twins were alive and resided in Finland, a total of 5,563 twin subjects replied (response rates, 88 percent for males and 93 percent for females). Of these twins, parental report data on perinatal measures were available for 5,100. We hierarchically excluded 6 subjects with proxy respondents or a serious disability, 190 subjects because of missing or improbable information on height/weight at age 16 years, 178 subjects because of missing or improbable information on length/weight at birth, and 18 subjects for whom there were discrepancies between birth length, weight, and gestational age. Of the remaining 4,708 subjects (2,354 pairs), we excluded 92 pairs in which one of the twins had incomplete data and 74 pairs because of unknown zygosity (determined by a questionnaire method described elsewhere (53)). Our final analytical population, for whom data were complete on body size at birth and at age 16 years, consisted of 4,376 subjects (2,188 twin pairs). Of these twins, 702 (282 male and 420 female) pairs were monozygotic, 724 (368 male and 356 female) pairs were same-sex dizygotic, and 762 pairs were opposite-sex dizygotic.

In addition, when information on duration of gestation was used, we excluded 251 pairs because of missing or improbable gestational age. Furthermore, of these 1,937 pairs (3,874 subjects), 1,708 (3,416 subjects) had information on both parents’ height and 1,684 (3,368 subjects) on both parents’ BMI.

To include growth from birth to early adulthood, we repeated the analyses by using the follow-up questionnaire data for adolescents aged 18 years (both height and weight were reported for 3,917 subjects: 1,742 males and 2,175 females). Because the results were extremely similar to the ones for which the age-16-years data set was used (except that the adolescents had grown), the results for age 18 years are not presented in this paper.

The study protocol was approved by the Institutional Review Board of Indiana University, Bloomington, Indiana. The families were provided with information about the study at baseline and were given regular feedback during follow-up in the form of personal letters. The data protection board of Finland approved the maintenance of the study cohort database.

Measures of the twins

Birth lengths (in centimeters) and weights (in grams) of the twins were reported by their parents. Ponderal index (birth weight (in kilograms) divided by birth length (in meters) cubed) was used as a measure of relative birth weight. The parents (usually the mother) also reported the duration of gestation, twins’ birth order, and whether the mother smoked during the twin gestation.

The twins reported their current height (in centimeters) and their weight (in kilograms) in adolescence (age 16–18 years). BMI (weight (in kilograms) divided by height (in meters) squared) was used as a measure of relative weight. “Overweight” twins were defined as those whose BMI equaled or exceeded 25 kg/m² (54).

Six categories of birth length and birth weight were created to adjust these measures for gestational age. Because no national reference tables were available for twins’ birth lengths or weights according to gestational ages, we divided the twins into percentile groups with regard to length and weight at birth for every gestational week, as Rasmussen and Johansson (16) did with their singleton data. The following categories were used to assess the pattern of tracking of body size. Subjects in birth length category 1 comprised those whose birth length was at or below the 5th percentile of twins for any given gestational age (from 27 to 42 weeks). Correspondingly, those in the 6th to ≤25th percentile formed category 2, 26th to ≤50th percentile category...
3, 51st to ≤75th percentile category 4, 76th to ≤95th percentile category 5, and >95th percentile category 6. Birth weight categories 1–6 were created similarly.

If birth length was ≤25th percentile for gestational age (birth length categories 1–2), the subject was defined as “short.” For a 26th–75th birth length percentile (birth length categories 3–4), the subject was defined as “average” and for a percentile of >75th (birth length categories 5–6) as “long.” In the same manner, the newborns were classified as “light” (birth weight categories 1–2), “average” (birth weight categories 3–4), and “heavy” (birth weight categories 5–6). When these definitions were combined, the twins were divided into nine body size groups at birth. However, the “short and heavy” (n/H11005 26) and “long and light” (n = 7) groups were not analyzed because of small group sizes.

**Measures of the parents**

At twin age 16 years, the biologic parents of the twins individually reported their own height and weight at the present time and before the twin pregnancy began. For logistic regression analyses, mothers’ heights were divided into three groups: <160 cm, 160–169 cm, and ≥170 cm. Similarly, fathers’ heights were grouped as <170 cm, 170–179 cm, and ≥180 cm. In figure 1 (tracking of body size), parental heights were combined by using midparental height ((mother’s height + father’s height)/2) in grouping parents as short (≤25th percentile (≤167.5 cm)), average (26th–74th percentile (167.6–173.9 cm)), and tall (≥75th percentile (≥174.0 cm)). Mother’s and father’s overweight status (<25 kg/m² vs. ≥25 kg/m²) was treated similarly and was combined in figure 2 according to the number of parents who were overweight (neither, one, or both).

The socioeconomic status of the mother and the father was determined by their reported occupations at the time of the survey, according to the Statistical Office of Finland classification (55), as follows: 1) upper-level employees, 2) lower-level employees, 3) manual workers, 4) self-employed persons, 5) farmers, and 6) others including students, unemployed persons, pensioners, and missing information. Family structure was categorized according to whether the twins lived with their 1) mother and father, 2) mother and stepfather, 3) father and stepmother, 4) mother only, or 5) father only. All other parental characteristics used in the analyses were obtained from the biologic parents, irrespective of with whom the twins resided.

**Statistical analyses**

The descriptive analyses were performed by using the SAS statistical software package (version 6.12; SAS Institute, Inc., Cary, North Carolina). Because our subjects were twins from twin pairs, and observations and their error terms between the members of a pair may be correlated, we adjusted for this clustering. Tests for equality of means and linear regression analyses were conducted with Stata statistical software (release 6.0; Stata Corporation, College Station, Texas) by using survey estimation procedures (SVYMEAN, SVYTEST, and SVYREG) to derive the proper variances and confidence intervals. For the same reason, logistic regression analyses with generalized estimating equations (56) were performed with SAS software by using the PROC GENMOD procedure. The odds ratios and their 95 percent confidence intervals for overweight at age 16 years, by different birth length and weight categories and body size groups, were adjusted for the following possible confounders: sex, zygosity, order of twin birth, family struc-

![FIGURE 1](image-url). Mean height, weight, and body mass index (BMI) of 3,416 Finnish twins (birth cohorts 1975–1979) at age 16 years (y), by six birth length categories and three parental height groups. Birth length categories: 1, ≤5th; 2, 6th–25th; 3, 26th–50th; 4, 51st–75th; 5, 76th–95th; and 6, >95th percentile at each gestational age. Parental height groups: *—+* short, ≤25th percentile (≤167.5 cm); —— average, 26th–74th percentile (167.6–173.9 cm); and ++ tall, ≥75th percentile (≥174.0 cm) of midparental height.

Tracking of body size from birth to age 16 years

In regression analyses, both length and weight at birth predicted height at age 16 years (table 2). For every centimeter in birth length, adolescent height increased 0.9 cm, but BMI increased only marginally (0.08 kg/m²). Furthermore, for every kilogram at birth, adolescent height increased 4 cm, and BMI increased 0.5 kg/m². Ponderal index as a measure of fatness at birth predicted adolescent BMI, but height did not. Those who were overweight at age 16 years weighed more (2,781 g) and had a higher ponderal index (25.7 kg/m³) at birth than those who were not overweight at age 16 years (weight: 2,681 g, \( p < 0.01 \); ponderal index: 25.3 kg/m³, \( p = 0.014 \)).

After we adjusted for gestational age, we found that the heavier their birth length or birth weight category, the taller and heavier subjects were at age 16 years. From birth length categories 1 to 6, height at age 16 years increased linearly (respectively, in males from 169.9 cm to 180.0 cm; in females from 162.3 cm to 169.6 cm), as was the case with weight at age 16 years (respectively, in males from 59.2 kg to 66.2 kg; in females from 52.9 kg to 59.9 kg). From birth length categories 1 to 6, no clear association was found for BMI at age 16 years for males (about 20.4 kg/m² in all groups), but a linear increase was detected in females (from 20.1 kg/m² to 20.8 kg/m²). However, from

**TABLE 1. Descriptive statistics† at birth and at age 16 years for 4,376 Finnish twins (birth cohorts 1975–1979), FinnTwin16 study**

<table>
<thead>
<tr>
<th></th>
<th>All twins (n = 4,376)</th>
<th>Males (n = 2,062)</th>
<th>Females (n = 2,314)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>At birth</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length (cm)</td>
<td>47.2 (0.05)</td>
<td>47.6 (0.7)</td>
<td>46.9 (0.7)**</td>
</tr>
<tr>
<td>Weight (g)</td>
<td>2,685 (10.0)**</td>
<td>2,750 (14.0)</td>
<td>2,627 (12.2)**</td>
</tr>
<tr>
<td>Ponderal index (kg/m³)</td>
<td>25.3 (0.06)</td>
<td>25.3 (0.07)</td>
<td>25.3 (0.07)</td>
</tr>
<tr>
<td><strong>At age 16 years</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>169.8 (0.15)</td>
<td>175.2 (0.19)</td>
<td>165.0 (0.14)**</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>58.9 (0.17)**</td>
<td>63.0 (0.23)</td>
<td>55.2 (0.19)**</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>20.3 (0.04)</td>
<td>20.4 (0.06)</td>
<td>20.2 (0.06)*</td>
</tr>
<tr>
<td>Overweight§ (%)</td>
<td>4.3</td>
<td>4.4</td>
<td>4.2</td>
</tr>
</tbody>
</table>

* \( p < 0.01 \); ** \( p < 0.001 \). Wald test for equality of means (log-transformed values) between males and females.
† Except for overweight, all values expressed as mean (standard error).
‡ BMI, body mass index.
§ BMI ≥ 25 kg/m².
**TABLE 2.** Univariate regression analysis coefficients of height, weight, and body mass index at age 16 years on length, weight, and ponderal index at birth for 4,376 Finnish twins from birth cohorts 1975–1979, FinnTwin16 study†

<table>
<thead>
<tr>
<th>At birth</th>
<th>At age 16 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Height (cm)</td>
</tr>
<tr>
<td></td>
<td>Coefficient</td>
</tr>
<tr>
<td>Length (cm)</td>
<td>0.90</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>4.02</td>
</tr>
<tr>
<td>Ponderal index (kg/m³)</td>
<td>-0.026</td>
</tr>
</tbody>
</table>

* p values from the corresponding regression analyses with log-transformed measures.

birth weight categories 1 to 6, all measures at age 16 years increased linearly in both sexes (height: from 171.1 cm to 178.1 cm in males, from 162.7 cm to 168.2 cm in females; weight: from 58.9 kg to 67.1 kg in males, from 52.3 kg to 59.0 kg in females; BMI: from 20.0 kg/m² to 21.1 kg/m² in males, from 19.7 kg/m² to 20.9 kg/m² in females). The odds ratios for overweight showed no clear pattern for different birth length categories (data not shown), but the higher the birth weight category, the higher the risk for overweight, especially after adjustment for possible confounders (table 3).

Body size also tracked from birth to adolescence when length and weight at birth were combined (table 4). Subjects who were short and light at birth were still short and light at age 16 years, and those who were long and heavy at birth were tall and heavy at age 16 years. Birth weight for gestational age seemed to have a positive effect on adolescent height as well as on weight, whereas birth length had no such effect on adolescent weight but was a clear indicator of adolescent height. Subjects who were of average length and heavy weight at birth had the highest risk for overweight in adolescence.

**Parental body size**

*Longitudinal analyses.* Figures 1 and 2 clarify the effects of parental height and BMI, respectively, on the tracking of body size from birth to adulthood. The effects were similar for males and females; therefore, we combined the data for both sexes. Among twins, birth length for gestational age was an important predictor for height and weight but not BMI at age 16 years (figure 1). However, the effect of parents’ height status was remarkable on the twin’s outcome. In all birth length categories, the twins of tall parents were tallest and therefore also heaviest in mass (kilograms) at age 16 years. On the other hand, the twins of short parents were consistently shortest (and lightest in mass); twins of average parents were in between those two extremes. Parents’ height group had no effect on twins’ BMI at age 16 years.

Heavy birth weight for gestational age was an indicator of tall height and of heavy weight and high BMI at age 16 years (figure 2). Parents’ overweight significantly influenced the effects of birth weight on adolescent weight and BMI but not on height. Thus, the higher the birth weight category and the number of overweight parents, the heavier the twins were at age 16 years.

**TABLE 3.** Odds ratios and 95% confidence intervals for overweight* in 4,376 Finnish twins (birth cohorts 1975–1979) at age 16 years, by birth weight category, FinnTwin16 study

<table>
<thead>
<tr>
<th>Birth weight category: birth weight percentile at each gestational age</th>
<th>At age 16 years</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>OR†</td>
<td>95% CI</td>
<td>No.</td>
<td>OR†</td>
<td>95% CI</td>
</tr>
<tr>
<td>1: ≤5th§</td>
<td>78</td>
<td>1.0</td>
<td></td>
<td>133</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>2: 6th–25th</td>
<td>273</td>
<td>1.5</td>
<td>0.3, 6.6</td>
<td>522</td>
<td>1.1</td>
<td>0.5, 2.6</td>
</tr>
<tr>
<td>3: 26th–50th</td>
<td>433</td>
<td>1.4</td>
<td>0.3, 5.8</td>
<td>519</td>
<td>1.0</td>
<td>0.4, 2.2</td>
</tr>
<tr>
<td>4: 51st–75th</td>
<td>478</td>
<td>2.1</td>
<td>0.5, 8.1</td>
<td>489</td>
<td>0.9</td>
<td>0.4, 2.3</td>
</tr>
<tr>
<td>5: 76th–95th</td>
<td>430</td>
<td>2.0</td>
<td>0.5, 8.2</td>
<td>340</td>
<td>2.0</td>
<td>0.8, 4.8</td>
</tr>
<tr>
<td>6: &gt;95th</td>
<td>121</td>
<td>1.5</td>
<td>0.3, 7.8</td>
<td>58</td>
<td>3.0</td>
<td>0.9, 9.9</td>
</tr>
<tr>
<td>Missing§</td>
<td>249</td>
<td>2.6</td>
<td>0.6, 11.1</td>
<td>253</td>
<td>2.0</td>
<td>0.7, 5.1</td>
</tr>
</tbody>
</table>

* Body mass index: ≥25 kg/m² vs. <25 kg/m².
† Adjusted for sex, zygosity, order of twin birth, family structure, mother’s and father’s height group, mother’s and father’s overweight, mother’s and father’s occupation (all at twin age 16 years), mother’s age at twin birth, and mother’s smoking during twin pregnancy.
‡ OR, odds ratio; CI, confidence interval.
§ Reference group.
¶ Information on gestational age missing.

TABLE 4. Mean ponderal index at birth, and height, body mass index, and prevalence of and odds ratio and 95% confidence interval for overweight* at age 16 years in 4,376 Finnish twins (birth cohorts 1975–1979), by birth length and birth weight group, FinnTwin16 study

<table>
<thead>
<tr>
<th>Birth length and birth weight group†</th>
<th>All twins at birth</th>
<th>Males</th>
<th>At age 16 years</th>
<th>Females</th>
<th>All twins</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Ponderal index (kg/m²)</td>
<td>No.</td>
<td>Height (cm)</td>
<td>BMI (kg/m²)</td>
</tr>
<tr>
<td>1: short and light¶</td>
<td>796</td>
<td>24.4</td>
<td>269</td>
<td>172.1</td>
<td>20.4</td>
</tr>
<tr>
<td>2: short and average</td>
<td>455</td>
<td>27.4</td>
<td>206</td>
<td>173.3</td>
<td>20.6</td>
</tr>
<tr>
<td>3: average and light</td>
<td>203</td>
<td>21.1</td>
<td>80</td>
<td>173.8</td>
<td>19.8</td>
</tr>
<tr>
<td>4: average and average</td>
<td>1,284</td>
<td>24.9</td>
<td>606</td>
<td>175.0</td>
<td>20.2</td>
</tr>
<tr>
<td>5: average and heavy</td>
<td>442</td>
<td>28.0</td>
<td>223</td>
<td>176.4</td>
<td>20.8</td>
</tr>
<tr>
<td>6: long and average</td>
<td>180</td>
<td>22.2</td>
<td>99</td>
<td>177.5</td>
<td>20.5</td>
</tr>
<tr>
<td>7: long and heavy</td>
<td>481</td>
<td>25.7</td>
<td>314</td>
<td>178.7</td>
<td>20.6</td>
</tr>
<tr>
<td>Missing‡</td>
<td>535</td>
<td>25.6</td>
<td>285</td>
<td>174.0</td>
<td>20.5</td>
</tr>
</tbody>
</table>

* Body mass index (BMI): ≥25 kg/m² vs. <25 kg/m². † Short: ≤25th percentile; average: 26th–75th percentile; long: >75th percentile of birth length at each gestational age. Light: ≤25th percentile; average: 26th–75th percentile; heavy: >75th percentile of birth weight at each gestational age. ‡ OR, odds ratio; CI, confidence interval. § Odds for overweight adjusted for sex, zygosity, order of twin birth, family structure, mother's and father's height group, mother's and father's overweight, mother's and father's occupation (all at twin age 16 years), mother's age at twin birth, and mother's smoking during twin pregnancy. ¶ Reference group. # Gestational age missing for 502 subjects; data on two body size groups (short and heavy: 14 males, 12 females; long and light: 2 males, 5 females) not presented in the table; therefore, total no. missing = 535.

Cross-sectional analyses. When parental body size, socioeconomic status, and mother’s smoking during pregnancy were taken into account in regression models, we found that for newborn body size, maternal effects were stronger than paternal effects; in adolescence, however, the effects were equal (detailed data not shown). Both mother’s height and BMI were positively associated with newborn length and weight, but father’s height predicted only the length and father’s BMI only the weight of the newborn. In adolescence, both parents’ height predicted the height of the offspring, and parents’ BMI predicted the BMI of the offspring.

To summarize, after adjustment for gestational age, birth length primarily predicted adolescent height (and therefore also weight). However, birth weight predicted all of the body measures (height, weight, and BMI) in adolescence. Combining both length and weight at birth illustrated that the body size groups so formed remained almost unchanged from birth to age 16–18 years. The highest subsequent prevalence of and risk for overweight occurred in the group of subjects of average birth length but high birth weight. In addition, parents’ size had a notable effect on the tracking phenomenon. Parents’ height influenced the tracking of birth length; subjects in the shortest length category but who had tall parents were as tall in adolescence as subjects who themselves were in the longest category but had short parents. Furthermore, the twins in the lowest category of birth length and who had short parents were almost 20 cm shorter at age 16 years compared with those in the highest birth length category who had tall parents. Parents’ overweight markedly influenced the effect of birth weight on body habitus at age 16 years. Subjects in the lowest birth weight category who had two overweight parents were as heavy (BMI) as those in the highest birth weight category who had no overweight parents. Thus, the difference between the two extremes, low birth weight and no overweight parents versus high birth weight and two overweight parents, was approximately two BMI units (kg/m²) at age 16 years, which is equivalent to a 6-kg difference for a body height of 170 cm.

DISCUSSION

This study clearly demonstrated the tracking of body size from birth to adolescence in 4,376 subjects representative of all Finnish twins born in 1975–1979. With this population, and by using length, weight, and ponderal index at birth through the entire range of gestational ages and heights, weights, and BMIs at age 16–18 years, we were able to replicate previous singleton results (12, 14–20) demonstrating tracking of body size from birth to adulthood. Subjects who were small at birth remained, on average, small, and those who were large at birth were large throughout the growth period. We found a striking resemblance to findings from a methodologically similar study of singleton Swedish males aged 18 years (16); with every increase in birth length or birth weight for gestational age, adult height, weight, and BMI increased. The strongest positive associations were found for birth weight and length and adult height and, on the other hand, birth weight and adult BMI. In both the present and the Swedish (16) studies, the high birth weight and normal birth length group, followed by the high birth weight and high birth length for gestational age group, had an increased risk for later obesity.

The most widely cited defect in previous studies of the tracking of body size from birth to adulthood is the absence of information about the parents of subjects. The present study clearly demonstrated that inclusion of parents’ height influenced the tracking of the subject’s body size. Combining both length and weight at birth illustrated that the body size groups so formed remained almost unchanged from birth to age 16–18 years. The highest subsequent prevalence of and risk for overweight occurred in the group of subjects of average birth length but high birth weight. In addition, parents’ size had a notable effect on the tracking phenomenon. Parents’ height influenced the tracking of birth length; subjects in the shortest length category but who had tall parents were as tall in adolescence as subjects who themselves were in the longest category but had short parents. Furthermore, the twins in the lowest category of birth length and who had short parents were almost 20 cm shorter at age 16 years compared with those in the highest birth length category who had tall parents. Parents’ overweight markedly influenced the effect of birth weight on body habitus at age 16 years. Subjects in the lowest birth weight category who had two overweight parents were as heavy (BMI) as those in the highest birth weight category who had no overweight parents. Thus, the difference between the two extremes, low birth weight and no overweight parents versus high birth weight and two overweight parents, was approximately two BMI units (kg/m²) at age 16 years, which is equivalent to a 6-kg difference for a body height of 170 cm.
height and inclusion of parents’ BMI that of the subject’s BMI. Maternal effects on the tracking of body size were also detected in the US Nurses’ Health Study (19), in which women who chose thin figures to represent their mothers had, overall, only a minimal risk while women who chose obese figures to describe their mothers had a multifold risk, in all birth weight categories, of becoming obese. However, neither the present nor previous studies have been able to distinguish the contribution of genetic and environmental effects to the transmission of body size from generation to generation and the tracking of body size from birth to adulthood.

A limitation of the present study is that all measures were reported by the subjects themselves or by their parents. Self-reports tend to shift to a more desirable outcome: tall and slim figures are overestimated and the prevalences of overweight are underestimated. It can be assumed that the effects are of the same magnitude for both adolescents (57) and their parents (58). Furthermore, the correlation coefficient between measured and self-reported heights and weights has commonly been more than 0.90 (58, 59). Parental (usually maternal) recall of birth weights and gestational ages is another source of possible bias. However, maternal report is widely used and is regarded as sufficiently accurate for epidemiologic work (60). The accuracy between maternal recall and medical records of birth weights has reached a kappa value of 0.89 and that of gestational age 0.85 (61); when a disagreement was detected in the McCormick and Brooks-Gunn study of singletons, mothers were likely to recall a lower birth weight. Whether this finding is true for twins is not known, but the possible biases in reporting were unlikely to be correlated with other measures and thus unlikely to change the results. Regarding gestational age, the greatest disagreement exists for postdate infants (61), which practically did not occur in our data on twins.

Another methodological issue is our use of BMI as an indicator of body size. This use was justified, however, because we attempted to capture body habitus in general (both lean and fat mass). In fact, lean body mass, similar to fat mass, is higher in obese subjects. BMI cannot be used to compare children or adolescents of different ages, but, in this study, all adolescents were the same age. Although it can be argued that the World Health Organization’s (54) cut-point of overweight (>25 kg/m²) is not applicable to adolescents aged 16 years, this cutpoint lies close to the recent US reference BMI for Whites at age 16 years (85th percentile: 25.4 kg/m² for boys, 25.1 kg/m² for girls) (62).

In the future, it will be important to study development and tracking of adiposity distribution and its contributions to adult diseases. A growth failure in utero seems to increase the tendency to store fat abdominally (63–66), which may explain the controversy between the relation of low birth weight to chronic diseases and the relation of high adult weight to chronic diseases. It seems that, although those persons of a high birth weight are more often overweight than those of a low birth weight, the most undesirable individual health effects occur when a low birth weight infant develops into an obese adult.

Conclusions

This study offers some new pieces for the puzzle of tracking of body size. Twins showed a pattern of tracking of body size from birth to late adolescence similar to that for singletons. Parents’ body size had a sizable effect on the tracking phenomenon. Height in adolescence was predicted by length and weight at birth and by parents’ height, whereas BMI was predicted by birth weight and parents’ BMI. An especially high risk of overweight was found for subjects who were of normal length at birth but had a high birth weight and for those who had an overweight mother and/or father. These results create the need for two types of further research: 1) assessing the enduring health effects of different body builds when evaluating the findings from this and other studies that heavy infants may be at risk for later obesity but light infants for later abdominal obesity; and 2) distinguishing the role of genes and environment in the tracking of body size from birth to adulthood.

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