Birth Weight and Length as Predictors for Adult Height

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Adult height has been found to be inversely associated with mortality. Recently, it has been suggested that growth in utero is linked with adult risk of several chronic diseases. The authors examined possible associations between birth weight, birth length, and adult height in young Danish men. They conducted the study in the fifth conscription district of Denmark including all the men born after January 1, 1973 who were residents in the study area during the period August 1, 1993 to July 31, 1994. The Danish Medical Birth Register contains information on all births in Denmark since January 1, 1973. Data on height from the Conscription Register were linked to the Danish Medical Birth Register in 4,300 conscripts examined. Nearly all Danish men have to register with the draft board around age 18 years of age where they undergo a physical examination. There was a strong positive association between birth weight and adult height; for subjects with birth weight ≤2,500 g, mean height was 175.7 cm, while for those with birth weight ≥4,501 g, mean height was 184.1 cm. A positive association was also found between birth length and adult height. For subjects with birth length <47 cm, mean adult height was 175.2 cm, increasing to 184.3 cm at birth length >56 cm. The associations between birth length and adult height persisted after adjustment for birth weight, gestational age, and other confounders, while the associations between birth weight and adult height almost disappeared when adjusting for birth length and the same confounders. Genetic and/or environmental factors operating both during the pre- and postnatal period may be responsible for the association between birth length and adult height. Am J Epidemiol 1999;149:726-9.

Materials and Methods

We conducted the study in the fifth conscription district of Denmark, which mainly includes the counties of North Jutland and Viborg. The population size of this region is approximately 700,000, about 14 percent of the total population in Denmark. Nearly all Danish men have to report to the draft board around 18 years of age and rarely beyond age 26 years; at the draft
board, they undergo physical examination and intelligence testing. A few were exempted from examination. We studied all the men examined who were born after January 1, 1973 and residents in the study area during the period August 1, 1993 to July 31, 1994.

We linked data on height from the examination to the Danish Medical Birth Register by means of the central personal registration number (CPR number), which has been given to all Danes at birth since 1968. The CPR number is used in all Danish data sources, thus making linkage between data bases simple and valid. The Birth Register contains information on all births in Denmark since January 1, 1973 and data are collected for ongoing statistics. The data are obtained from the notifications of birth, which are recorded by the midwife attending the delivery. In the Birth Register, information on birth weight is divided into categories of 250 g, and we used midpoints of the categories in the analyses. Birth length was reported to the register in centimeters, and was included in the regression analysis as a continuous variable.

We first examined adult height in relation to the study variables. To control for confounding, we fitted linear regression models to the data that included weight and length at time of birth, birth order, gestational age, marital status, mother’s age, and employment status. To obtain a clearer picture of the shape of the relation between birth length/birth weight and adult height, we used confounder-adjusted quadratic splines to smooth the curves (16).

The study was approved by the Regional Ethics Committee and the Danish Data Protection Agency.

RESULTS

We identified 4,805 draftees born after January 1, 1973 during the study period. Of these, 4,300 draftees underwent a medical examination. The majority of the remaining 505 men were exempted because of asthma, juvenile osteochondrosis, or epilepsy.

Table 1 shows the association between birth weight and adult height at the draft board examination. There was a strong positive association between birth weight and adult height; at birth weight ≤2,500 g, the mean height was 175.7 cm, while at birth weight ≥4,501 g, it was 184.1 cm. Table 1 also shows a positive association between length at the time of birth and adult height. At birth length <47 cm, mean adult height was 175.2 cm, increasing to 184.3 cm at birth length >56 cm.

To improve our estimate of the shape of the dose-response curve relating the birth length to height, we fitted an unrestricted quadratic spline regression model with all covariates including birth weight. Figure 1 shows a strong association between birth length and adult height. The smoothed curve indicates a peak around 58 cm after which height declines slightly. Figure 2 presents the corresponding regression with birth weight as predictive variable and birth length included among the covariates. The curve indicates a positive adjusted association between birth weight and height, but much less pronounced than the association with birth length. There was a strong association between birth weight and length, but the spline curves indicate that birth length was a much stronger predictor for adult height than birth weight.

DISCUSSION

We found a clear association between birth length, birth weight, and adult height; the association was most pronounced for birth length, which outweighed the effect of birth weight in a common analysis. However, because birth weight is measured in categories and length as a continuous variable, some residual confounding of birth weight on the length and adult height association cannot be excluded. The association persisted when adjusted for possible effects of gestational age, birth order, mother’s age, marital status, and employment status.

Fetal growth is generally considered in terms of birth weight and not birth length, and it is consequently difficult to make comparisons with postnatal growth, which is most often expressed in length. A recent randomized trial in Java (17) showed that...
among women in the reproductive age, energy supplementation of the last 90 days of pregnancy increased postnatal growth and reduced malnutrition in preschool children. The most striking result was the greater effect on height than on weight. Adult height may thus be an indicator of early nutrition.

Our findings are in agreement with other studies of birth weight and height associations using somewhat different types of data and design. A recent population-based study that followed small for gestational age infants to adulthood (18) showed that they had a sevenfold higher risk of being short than subjects who were not born small for gestational age. Leger et al. (19) studied 236 full term singleton babies small for gestational age and 281 with normal birth weight. The target height was 174 cm versus 175 cm in men and 160 versus 162 in women. A study from Israel (4) found a strong association between birth weight and adult height regardless of ethnic and socioeconomic factors. Another Israeli study with 17 years follow-up of small for gestational age infants (9) found an increased risk of short stature at late adolescence.

It seems likely that implicit growth factors as well as genetic and environmental factors are operating. The biologic factors determining the growth of the fetus are the genetic makeup of the fetus combined with the utero-placental function and thus the substrate availability (17). The association between birth length and adult height may be explained by several factors that do not invoke in utero determinants of adult height: 1) tall stature has genetic determinants that may be expressed in infants as well as adults; 2) although we adjusted for some social factors, there may be residual confounding between stature and social and other environmental factors that affect both birth length and adult height. Secular trend studies within populations definitely demonstrate that common general environmental factors influence height of the members of the population.
population (20). On the other hand, several twin studies have shown that within the population variation in height at a given point in time is mainly attributable to genetic differences (5, 21). It has been hypothesised (15) that "metabolic programming" occurring at critical stages of early development causally determines the risk of adult diseases such as coronary heart disease, stroke, diabetes mellitus, and hypertension. However, several methodological problems, such as loss to follow-up and confounding by socioeconomic factors, suggest the advisability of cautious interpretations about the possible causal relations between fetal growth and risk of later disease (15).

ACKNOWLEDGMENTS

Supported by grants from Sygekassernes Helsefond (11/064-94). The activities of the Danish Epidemiology Science Centre are financed by a grant from the Danish National Research Foundation.

The authors thank Hans Jørgen Pedersen for helping with the data collection.

REFERENCES