Family social class, maternal body mass index, childhood body mass index, and age at menarche as predictors of adult obesity[1–3]

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ABSTRACT
Background: Obesity is an increasingly prevalent nutritional disorder throughout the world and is a risk factor for many chronic diseases. The prevalence of obesity increases with age.
Objective: The objective was to evaluate the associations between BMI at 31 y of age and family social class during early childhood, maternal body mass index (BMI) before pregnancy, BMI at birth and at 1 and 14 y of age, and age at menarche.
Design: This was a longitudinal study of the northern Finland birth cohort for 1966. Subjects were measured at birth and at 1, 14, and 31 y of age. The analysis was restricted to individuals for whom BMI data were available for all measurement points (n = 2876 males and 3404 females).
Results: The mean BMI at birth was highest in offspring from the highest social classes, but BMI was inversely related to social class at 1 y. BMI, the waist-to-hip ratio, and the proportion of obese subjects were inversely related to social class at 31 y. The heavier the mother, the heavier the offspring from birth to 31 y. The paired analyses between maternal BMI and daughter's BMI at 31 y showed no significant difference in BMI after adjustment for the age difference. BMI at 14 y was the most important predictor of BMI at 31 y. Early menarche in females was associated with a higher BMI at 14 and 31 y.
Conclusions: Differences in BMI by social class are formed at least partly during early childhood. Low social class of the child's family, a high maternal BMI before pregnancy, a high BMI during adolescence, and early menarche are predictors of obesity in adulthood. *Am J Clin Nutr* 2001;74:287–94.

KEY WORDS Body mass index, BMI, obesity, social class, longitudinal studies, childhood, adolescence, adulthood, age at menarche, cohort study

INTRODUCTION

Obesity is an increasingly prevalent nutritional disorder throughout the world (1) and its prevalence increases with age (2–4). Obesity is a risk factor for many chronic diseases, such as cardiovascular diseases, type 2 diabetes, and musculoskeletal disorders (5). Obesity increases the risk of disability among young and middle-aged Finns and the probability of early work disability was shown to increase with an increasing body mass index (BMI) (6). Thus, the total costs attributable to obesity and its health consequences are huge (7). Besides the economic costs to society, obesity reduces the quality of life, and overweight during adolescence and young adulthood may even influence an individual's social class (8, 9).

Obesity is inversely related to socioeconomic status in the developed world, especially among white women (9). Children from lower social classes are more likely to become overweight or obese than are children from higher social classes and are more likely to remain overweight or obese throughout early adulthood (10, 11). Genetic factors are also related to the development of obesity, as was observed in some studies of twins and adopted persons (12–14). The likelihood that a child will become obese in adulthood is markedly increased if both of his or her parents are obese (15, 16), if he or she is obese during childhood or adolescence (4), or if puberty occurs at an early age (2). Most obese adults, however, were not obese as children (2–4). The percentage of obese adults who were obese as children varies from 5% to 60% (4), depending on the cutoff used to define obesity.

Few longitudinal studies have examined the role of factors related to early childhood in adulthood obesity. In this longitudinal study of the northern Finland birth cohort for 1966, we hypothesized that a low family social class, a high maternal BMI, a high BMI during the subjects' childhood, and menarche occurring at an early age predict overweight and obesity at the age of 31 y. We are not aware of any previous studies that simultaneously considered these factors as predictors of obesity.

SUBJECTS AND METHODS

Subjects and study design

The northern Finland birth cohort for 1966 consists of 12 068 unselected children born in Finland's 2 northernmost provinces,

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Oulu and Lapland (17, 18). All mothers in this district whose calculated date of delivery fell between 1 January and 31 December 1966, were included in the study. However, a small percentage of the births occurred toward the end of 1965 and the beginning of 1967. The study included all live and stillborn infants with a birth weight of ≥600 g (18). Thirteen women delivered twice. The total number of children born was 12 231, of whom 12 058 were born alive, representing 96% of all births in the district.

At 31 y of age, 11 637 subjects (5906 men and 5731 women) were alive, but a questionnaire sent in 1997–1998 was not received by 96 of them. The analysis was additionally restricted to those who responded to the questionnaire (75.3%, n = 8767), who gave their written consent for the available data to be used for research purposes (n = 8690), and whose BMI data at birth and 1, 14, and 31 y of age were available (2876 men and 3404 women). This study was approved by the Ethical Committee of the Finnish Institute of Occupational Health and by the Ethical Committee of the University of Oulu.

Data collection

In 1965–1966, midwives at all antenatal and postnatal clinics in the provinces of Oulu and Lapland used structured study forms to collect information concerning the mother and her pregnancy from the sixth month of gestation until term (17). Data on the mother's weight, height, and social class were obtained from the standard forms for the pregnancy and from the maternity cards carried by all mothers. The offspring were followed up at 1, 14, and 31 y of age. Public health nurses used the special forms of the child health cards to collect data on growth at 1 y of age. Data for 14 y were obtained from a questionnaire that had been sent to the participants in 1980. The most recent follow-up, at 31 y, took place in 1997–1998; data were obtained from a questionnaire that had been sent to the participants, a clinical examination, or both.

Definition of explanatory variables and outcome

The mother's weight before pregnancy was recorded during her first visit to the antenatal clinic, which occurred on average during week 16 of gestation. Height was measured or self-reported. The mother's age was her age before pregnancy and was calculated as the date of the offspring's birth minus the gestational age of the offspring in days (or 280 d if the gestational age was missing) minus the date of the mother's birth. The age of the offspring was calculated as the date of the health examination minus the date of birth. Ages in years (ages in days/365.25) were used subsequently in the analyses.

Social classes were defined on the basis of the father's occupation in 1966 and its prestige (19, 20); data recorded in 1966 were used. Social classes I and II include occupations with the highest prestige and the longest education, eg, elementary school teachers, dentists, graduated engineers, priests, and office managers. Social class III includes skilled workers, eg, clerks and stewards, and social class IV includes unskilled workers, eg, domestic help, seamen, and cleaners. Those with no occupation or with an unknown occupation were included in social class IV. Farmers form a social class of their own. For 234 subjects with missing data, social class was based on corresponding information from the mother.

Body weight and height were measured at birth and at 1 and 31 y but were self-reported at 14 y. If weight or height was not measured at 31 y, self-reported measurements were used (30%). BMI (in kg/m^2) was calculated at birth and at 1, 14, and 31 y. Adult BMI at 31 y was classified as follows: underweight (<18.5), normal weight (18.5–24.9), overweight (25.0–29.9), and obese (≥30.0) (1). At birth, BMI was used for comparability with other measurement points because there appear to be no simple alternative indexes for weight relative to height for infants. Adolescence (age 14 y) overweight was defined as a BMI ≥85th to <95th percentile and obesity as a BMI ≥95th percentile, both by sex (21). The waist-to-hip ratio was measured as the ratio between the circumferences of the waist (at the level midway between the lowest rib margin and the iliac crest) and the hip (at the widest trochanters). For the female cohort members, age at menarche was indicated by the age at which menarche started, as reported in the questionnaire at 31 y.

Statistical methods

Cross-tabulation and the usual summary measures (means and SDs) were used as descriptive statistics. Analysis of covariance was used to adjust for maternal age in comparisons of mean BMIs across different social classes and between the maternal BMI categories because BMI increases with age (2, 3, 11, 22). Analysis of variance was used to compare mean BMIs across different categories of age at menarche. A paired analysis was performed for the difference between maternal BMI and the daughter's BMI, in which the age difference between mother and daughter was taken into account by a linear regression model. Linear regression analysis was used to investigate jointly the effect of the following predictor variables associated with BMI at 31 y: maternal BMI and age; social class as a categorical variable, with social class III as the reference class; birth weight; BMI at 1 and 14 y; and age at menarche for the women. Mean-centered values of the predictor variables were used, except for maternal BMI, which was centered to the mode of the class of normal weight (BMI of 22.50).

Analyses were based on only those subjects whose BMI data at birth and at 1, 14, and 31 y were available (n = 6280, 55% of those eligible). Data on the family's social class and the mother's age were available for all 6280 subjects, BMI was available for 5760 mothers, and the age at menarche was available for 3352 females born in 1966. Those subjects excluded because of missing data at some measurement point had an average BMI at birth and at 1 y that was not significantly different from those of the subjects who were included. Excluded subjects had a slightly higher mean BMI at 14 and 31 y. No significant difference between the BMIs of the mothers of included and excluded subjects was observed. The proportion of subjects from social class III was somewhat higher in the excluded subjects than in the included subjects (men: 31% compared with 23%; women: 30% compared with 24%). We used SPSS software for WINDOWS (version 9.0; SPSS Inc, Chicago).

RESULTS

Body weight, height, BMI, and waist-to-hip ratio of the 1966 cohort

A summary of the anthropometric measurements from birth to 31 y is presented in **Table 1**. At 31 y, 40% of the men and 20% of the women were classified as overweight and 8% of the men and 9% of the women were classified as obese (**Table 2**). At 31 y, the proportion of men with abdominal obesity was 5% [waist-to-hip

TABLE 1
Weight, height, and BMI at birth and at 1, 14, and 31 y of age and waist circumference and waist-to-hip ratio (WHR) at 31 y of age[1]

	Weight	Height	BMI	Waist[2]	WHR[2]
	kg	*cm*	*kg/m²*	*cm*	
Males (n = 2876)					
Birth	3.54 ± 0.52	51 ± 2	13.7 ± 1.6	NA	NA
1 y	10.4 ± 0.9	76 ± 3	17.8 ± 1.4	NA	NA
14 y	52.2 ± 9.6	165 ± 8	19.2 ± 2.5	NA	NA
31 y	80.0 ± 12.4	178 ± 6	25.2 ± 3.6	89 ± 10	0.91 ± 0.06
Females (n = 3404)					
Birth	3.42 ± 0.50	50 ± 2	13.7 ± 1.3	NA	NA
1 y	9.9 ± 1.0	75 ± 3	17.6 ± 1.5	NA	NA
14 y	50.4 ± 7.7	161 ± 6	19.3 ± 2.5	NA	NA
31 y	64.7 ± 12.5	165 ± 6	23.8 ± 4.4	79 ± 12	0.81 ± 0.08

[1] $\bar{x}$ ± SD. NA, not available.
[2] n = 1996 males and 2217 females.

ratio (WHR) > 1.00 (1)] and that of women was 21% [WHR > 0.85 (1)]; 12% of men and 6% of women had a waist circumference ≥100 cm.

BMI of the 1966 cohort from birth to 31 y by social class

BMIs tended to be lowest in social classes I and II, at 1 and 31 y and greatest in social classes I and II at birth (**Table 3**). These differences in BMI remained after adjustment for maternal BMI (data not shown) and maternal age. Correspondingly, the proportion of overweight (BMI: 25.0–29.9) and obese (BMI ≥ 30.0) 31-y-olds was lowest in men in social classes I and II (Table 2). At 14 y, BMIs did not differ significantly between the social classes. In 31-y-old men, mean waist and hip circumferences and WHRs did not differ significantly between the social classes (Table 3). In women, waist circumference and WHRs were highest in those in the farming class and from social class IV.

Maternal BMI by social class

The average BMI of mothers was the highest in the farming class (social classes I and II: 22.7 ± 2.8; social class III: 22.9 ± 2.9; social class IV: 23.1 ± 2.9; farming class: 23.7 ± 2.9; global $P < 0.001$ by analysis of covariance adjusted for age). The higher BMI of the mothers in social class IV and in farming class was evident also in the proportion of mothers classified as overweight or obese: 28% and 8%, respectively, in the farming class compared with 18% and 2%, respectively, in social classes I and II and III (Table 2).

BMI of offspring from birth to 31 y of age by maternal BMI

Children of overweight or obese mothers had higher mean BMIs at each age point than did children born to underweight or normal-weight mothers (**Table 4**). At 31 y, overweight and obesity were more common in subjects whose mothers were overweight

TABLE 2
Proportions of 31-y-old cohort members and their mothers who were underweight, normal weight, overweight, and obese, by the family's social class

Social class	Underweight (BMI <18.5)	Normal weight (BMI: 18.5–24.9)	Overweight (BMI: 25.0–29.9)	Obese (BMI ≥30.0)
		%		
Men				
I and II (n = 728)	<1	55	38	7
III (n = 951)	1	51	41	8
IV (n = 663)	<1	52	39	9
Farming (n = 534)	1	50	40	10
All (n = 2876)	1	52	40	8
Women[1]				
I and II (n = 840)	4	70	19	8
III (n = 1089)	3	70	20	7
IV (n = 820)	4	62	23	11
Farming (n = 655)	3	68	21	9
All (n = 3404)	3	68	20	9
Mothers[2]				
I and II (n = 1504)	3	78	18	2
III (n = 1906)	4	78	16	2
IV (n = 1287)	4	77	16	3
Farming (n = 1063)	1	63	28	8
All (n = 5760)	3	75	19	3

[1] $P = 0.027$ (chi-square test).
[2] $P < 0.001$ (chi-square test).

TABLE 3
BMI at birth and at 1, 14, and 31 y of age and waist and hip circumference and waist-to-hip ratio at 31 y of age for male and female members of the cohort for 1966, by the family's social class[1]

	Males				Females			
	I and II	III	IV	Farming	I and II	III	IV	Farming
BMI (kg/m^2)[2]								
n	728	951	663	533	840	1089	820	654
Birth	13.9 ± 1.3	13.7 ± 1.3[3]	13.6 ± 1.3[4]	13.7 ± 1.4[5]	13.8 ± 1.3	13.6 ± 1.3[6]	13.6 ± 1.3[4]	13.7 ± 1.4[7]
1 y	17.7 ± 1.4	17.8 ± 1.4	17.9 ± 1.4[8]	17.9 ± 1.4[9]	17.5 ± 1.5	17.4 ± 1.5	17.6 ± 1.5	17.8 ± 1.5[6]
14 y	19.2 ± 2.5	19.2 ± 2.5	19.1 ± 2.5	19.1 ± 2.6	19.2 ± 2.5	19.3 ± 2.5	19.4 ± 2.5	19.4 ± 2.6
31 y	25.0 ± 3.6	25.1 ± 3.6	25.3 ± 3.6	25.4 ± 3.7[10]	23.4 ± 4.4	23.7 ± 4.5	24.4 ± 4.4[4]	23.8 ± 4.6[11]
Waist and hip								
n	499	650	451	396	528	732	513	444
Waist circumference (cm)	88 ± 10	89 ± 10	88 ± 9	89 ± 10	78 ± 11	78 ± 11	80 ± 14[6]	79 ± 12[4]
Hip circumference (cm)	97 ± 6	97 ± 6	97 ± 6	97 ± 7	97 ± 9	97 ± 9	98 ± 9	97 ± 8
Waist-to-hip ratio	0.91 ± 0.06	0.91 ± 0.06	0.91 ± 0.06	0.92 ± 0.05[12]	0.80 ± 0.08	0.81 ± 0.08	0.82 ± 0.08[6]	0.81 ± 0.07[4]

[1] $\bar{x}$ ± SD.
[2] Adjusted for the mother's age by analysis of covariance.
[3–12] Significantly different from social class I and II: [3] $P = 0.021$, [4] $P < 0.001$, [5] $P = 0.034$, [6] $P < 0.001$, [7] $P = 0.074$, [8] $P = 0.011$, [9] $P = 0.002$, [10] $P = 0.023$, [11] $P = 0.061$, [12] $P = 0.043$.

or obese before pregnancy (men: 43% overweight and 12% obese; women: 27% overweight and 14% obese) than in subjects whose mothers were underweight or of normal weight (men: 39% overweight and 7% obese; women: 18% overweight and 7% obese; $P < 0.001$, chi-square test). Circumferences of the waist and hip and WHRs of the offspring at 31 y increased as maternal BMI increased.

Comparison between mothers and their 31-y-old daughters

The estimated linear regression line for the difference in BMIs between each mother and her daughter was as follows:

$$\text{BMI difference} = (0.13 + 0.20) \times \text{age difference} \quad (1)$$

The point estimate of the intercept parameter (0.13) and its 95% CI (−0.07, 0.33) indicates that no significant differences in BMI were observed between mothers and their daughters when the age difference was taken into account.

To what extent did BMI in childhood predict obesity in adulthood?

BMI at 14 y was a more important predictor of adult BMI than was BMI at birth or 1 y (**Tables 5** and **6**). Of males with a low birth weight (<3000 g), 39% were overweight and 8% were obese at 31 y (Table 5). Of males with a high birth weight (≥4000 g), 38% were overweight and 10% were obese at 31 y. Of females with a low birth weight, 20% were overweight and 8% were obese at 31 y. Of females with a high birth weight, 23% were overweight and 10% were obese at 31 y.

Of the males who were overweight at 14 y, 56% were overweight and 25% were obese at 31 y (Table 5). Of the males who were obese at 14 y, 41% were overweight and 47% were obese at 31 y. Of the females who were overweight at 14 y, 42% were still overweight and 22% were obese at 31 y. Of the females who were obese at 14 y, 27% were overweight and 55% were obese at 31 y.

TABLE 4
BMI at birth and at 1, 14, and 31 y of age and waist and hip circumferences and waist-to-hip ratio at 31 y of age, by sex and by maternal BMI classification[1]

	Maternal BMI							
	Underweight (BMI <18.5)		Normal weight (BMI: 18.5–24.9)		Overweight (BMI: 25.0–29.9)		Obese (BMI ≥30.0)	
	Males	Females	Males	Females	Males	Females	Males	Females
BMI[2]								
n	64	97	1994	2332	485	595	79	113
Birth	13.4 ± 1.3	13.3 ± 1.3	13.7 ± 1.3	13.6 ± 1.3	14.0 ± 1.3	14.0 ± 1.3	14.2 ± 1.3[3]	14.3 ± 1.3[3]
1 y	17.2 ± 1.4	17.1 ± 1.5	17.7 ± 1.4	17.5 ± 1.5	18.0 ± 1.4	17.7 ± 1.5	18.0 ± 1.4[3]	18.0 ± 1.5[3]
14 y	17.9 ± 2.5	18.0 ± 2.5	19.1 ± 2.5	19.1 ± 2.5	19.6 ± 2.6	20.0 ± 2.5	20.3 ± 2.5[3]	21.3 ± 2.5[3]
31 y	23.8 ± 3.5	22.1 ± 4.4	24.9 ± 3.6	23.3 ± 4.4	26.0 ± 3.6	25.1 ± 4.5	26.9 ± 3.6[3]	27.2 ± 4.4[3]
Waist and hip								
n	43	64	1355	1491	358	418	59	84
Waist circumference (cm)	87 ± 9	77 ± 12	88 ± 9	78 ± 11	90 ± 10	81 ± 13	93 ± 11[4]	86 ± 16[4]
Hip circumference (cm)	96 ± 6	95 ± 8	97 ± 6	96 ± 8	98 ± 7	99 ± 9	100 ± 7[4]	102 ± 10[4]
Waist-to-hip ratio	0.90 ± 0.05	0.81 ± 0.08	0.91 ± 0.06	0.80 ± 0.07	0.92 ± 0.06	0.83 ± 0.08	0.93 ± 0.06[4]	0.84 ± 0.09[4]

[1] $\bar{x}$ ± SD.
[2] Adjusted for the mother's age by analysis of covariance.
[3] $P < 0.001$ (analysis of covariance).
[4] $P < 0.001$ (ANOVA).

TABLE 5

Proportions of overweight (BMI: 25.0–29.9) and obese (BMI ≥ 30.0) subjects at 31 y of age by sex, birth weight, and age-specific BMI percentiles at 14 y of age

BMI percentile at 14 y[1]	Birth weight: <3000 g *n*	<3000 g Overweight at 31 y	<3000 g Obese at 31 y	3000–3999 g *n*	3000–3999 g Overweight at 31 y	3000–3999 g Obese at 31 y	≥4000 g *n*	≥4000 g Overweight at 31 y	≥4000 g Obese at 31 y	Overall *n*	Overall Overweight at 31 y	Overall Obese at 31 y
		%	%		%	%		%	%		%	%
Males												
<85th	326	37	5	1701	38	3	412	36	4	2439	38	4
85th to <95th	27	52	30	203	59	25	61	51	23	291	56	25
≥95th	11	45	36	102	40	47	33	42	52	146	41	47
Overall	364	39	8	2006	40	8	506	38	10	2876	40	8
Females												
<85th	482	17	4	2093	17	4	314	19	4	2889	18	4
85th to <95th	57	35	28	242	44	21	44	41	23	343	42	22
≥95th	20	30	55	121	24	55	31	35	52	172	27	55
Overall	559	20	8	2456	20	8	389	23	10	3404	20	9

[1] <85th, normal weight; 85th to <95th; overweight; ≥95, obese.

Linear regression analysis indicated that the most important predictor of BMI at 31 y of age was BMI at 14 y (Table 6; model 3). When BMI at 14 y was not included in the regression analysis (models 2 and 3), the most important predictors were maternal BMI and age, the subject's BMI at 1 y, and age at menarche in women.

Age at menarche and BMIs of the female cohort members

The mean (±SD) age at menarche was 12.9 ± 1.3 y (*n* = 3352), with menarche occurring in 12% of the females by 11 y, in 27% at 12 y, in 32% at 13 y, in 17% at 14 y, and in 12% at ≥15 y. Age at menarche did not differ significantly between the social classes. BMI at 14 and 31 y increased linearly as the age at menarche decreased (**Figure 1**), but no significant differences in BMI at birth or at 1 y were observed. At 31 y, the proportions of overweight and obese females were significantly higher in those who had matured earlier (by ≤11 y: 29% overweight and 15% obese; at ≥15 y: 16% overweight and 4% obese).

DISCUSSION

This study was undertaken to assess the association between the family's social class at birth, maternal BMI before pregnancy, and the development of obesity in the offspring from early in life through to adulthood. This study is unique because these factors have not been considered simultaneously in previous studies of the factors related to obesity in adulthood. The main finding was that the family's social class during the subject's childhood had a long-term influence on BMI. Differences in BMI between social classes were observed at birth, at 1 y, and at 31 y in both sexes. At 31 y, overweight and obesity were more common and the mean BMI was higher among offspring from lower social classes, as was also the case among mothers of the 1966 cohort.

The sample of the original northern Finland birth cohort for 1966 is representative of the original study population, although when the data were restricted to individuals for whom BMI data were available for all measurement points, the proportion of subjects included from the lowest social class was smaller than the proportion excluded. The missing data introduced a small selection bias, which diluted the differences between the social classes because obesity was found to be more common in the lowest social class. The mean BMIs of the 31-y-old men and women in the 1966 birth cohort are similar to those previously observed in 30–35- and 30–39-y-old Finns in the 1990s (23, 24) and are slightly lower than those observed in 33-y-olds from a British birth cohort for 1958 (2). The paired analyses of differences in BMIs between the mothers and their 31-y-old daughters showed that BMI did not increase markedly during the 31-y period. This finding agrees with that of another Finnish study that showed weight gain to remain unchanged in Finnish women over a 25-y period (25). This lack of increase in BMI may have been because energy and fat intakes have decreased in Finland in recent decades (26). These dietary changes have probably enhanced the promotion of weight control in women, especially because women usually consume a healthier diet than do men (27). Furthermore, women are usually more concerned about their body weight than are men (28) and may feel more societal pressure to control their body weight than do men. Unfortunately, corresponding data for fathers have not been collected; thus, we cannot compare the male offspring with their fathers. The prevalence of obesity has increased by ≈10–40% in most European countries over the past 10 y (1). This increase may be at least partly related to the aging of populations and also to changes in alcohol consumption and physical activity at work and during leisure time.

Our findings on the relation between BMI and social class add to the evidence emerging from other longitudinal studies (3, 10, 29). Although many cross-sectional studies show a consistent inverse relation between socioeconomic status and obesity for adult white women only (9, 30), longitudinal studies have consistently shown a relation in both sexes (3, 10, 11). For example, Braddon et al (3) reported differences in BMI by social class of origin in the British cohort of 1946 even at the age of 36 y, whereas Power and Moynihan (10) found such differences in the younger 1958 British cohort at 23 y of age. Data presented here for the Finnish 1966 cohort show a persisting influence of social class on BMI in both sexes during infancy and adulthood. We showed that this relation remained after adjustment for maternal BMI and age. To our knowledge this is a unique finding because most previous studies of socioeconomic status failed to adjust

TABLE 6
Estimated results of linear regression analyses of variables associated with BMI at 31 y of age, with social class III as the reference class

	Model 1			Model 2			Model 3		
	β	SE	95% CI	β	SE	95% CI	β	SE	95% CI
Men									
Constant	25.06	0.12	24.83, 25.30	25.09	0.12	24.85, 25.32	25.11	0.10	24.91, 25.32
Maternal BMI –22.5[1]	0.21	0.03	0.16, 0.26	0.19	0.03	0.14, 0.24	0.11	0.02	0.07, 0.16
Maternal age –27.1 y[2]	−0.06	0.01	−0.09, −0.04	−0.06	0.01	−0.08, −0.04	−0.05	0.01	−0.07, −0.03
Social classes I and II[3]	−0.18	0.18	−0.53, 0.17	−0.16	0.18	−0.51, 0.19	−0.19	0.16	−0.50, 0.11
Social class IV[3]	−0.01	0.19	−0.39, 0.36	−0.02	0.19	−0.39, 0.35	0.05	0.16	−0.27, 0.37
Social class Farming[3]	0.16	0.21	−0.25, 0.57	0.13	0.21	−0.27, 0.54	0.27	0.18	−0.09, 0.62
Birth weight –3.54 kg[2]	—	—	—	0.12	0.14	−0.15, 0.39	−0.02	0.12	−0.25, 0.22
BMI at 1 y –17.8[2]	—	—	—	0.29	0.05	0.19, 0.39	0.04	0.04	−0.05, 0.13
BMI at 14 y –19.2)[2]	—	—	—	—	—	—	0.71	0.02	0.67, 0.76
Women									
Constant	23.51	0.14	23.24, 23.78	23.62	0.13	23.36, 23.88	23.59	0.11	23.37, 23.81
Maternal BMI –22.5[1]	0.37	0.03	0.32, 0.42	0.32	0.03	0.27, 0.37	0.14	0.02	0.09, 0.18
Maternal age –27.1 y[2]	−0.06	0.01	−0.09, −0.04	−0.05	0.01	−0.08, −0.03	−0.01	0.01	−0.04, 0.01
Social classes I and II[3]	−0.19	0.20	−0.56, 0.24	−0.20	0.20	−0.59, 0.19	−0.11	0.17	−0.44, 0.22
Social class IV[3]	0.51	0.21	0.10, 0.92	0.39	0.20	−0.01, 0.79	0.48	0.17	0.14, 0.82
Social class Farming[3]	−0.19	0.23	−0.65, 0.27	−0.24	0.23	−0.69, 0.21	−0.03	0.19	−0.35, 0.41
Birth weight –3.42 kg[2]	—	—	—	−0.09	0.16	−0.39, 0.22	−0.21	0.13	−0.47, 0.05
BMI at 1 y –17.6[2]	—	—	—	0.44	0.05	0.34, 0.55	0.06	0.05	−0.03, 0.15
Age at menarche –12.9 y[2]	—	—	—	−0.56	0.06	−0.68, −0.45	−0.02	0.05	−0.12, 0.08
BMI at 14 y –19.3[2]	—	—	—	—	—	—	1.02	0.03	0.96, 1.07

[1] The BMI of 22.5 is the mode of the class of normal weight.
[2] Mean-centered values were used.
[3] 0 = no; 1 = yes.

for maternal BMI (3, 10, 11). These results strengthen the observations that parental socioeconomic status predicts the development of obesity in adulthood in whites (3, 10, 11) and that differences in the prevalence of obesity between social classes stem at least partly from the socioeconomic circumstances of the family of origin.

It is of interest that the association between the social class at birth and adult BMI (at 31 y) was preceded by a similar trend at 1 y, despite the reverse trend observed at birth. Differences in BMI between social classes seem to be formed, at least partly, during early childhood and may affect health in the long term because unhealthy habits and ill health are more common among low social classes (31–33). The nutritional and health status of mothers from low social classes are likely to be less than optimal for fetal growth, and thus the mean BMI at birth is lower in babies from families of low than from high social classes. In this northern Finland birth cohort for 1966, Rantakallio (34) found that babies with a low birth weight were often from low social classes. Poor nutrition during the intrauterine period or other reasons leading to low birth weight, such as the mother's smoking (20), may be associated with persistent disturbances of the regulation of hormones related to growth. These irreversible disturbances in hormonal mechanisms may increase the biological vulnerability of children with low birth weight to the effects of unhealthy habits and may increase their risk of developing obesity in adulthood. However, the relation appears to be more equivocal during childhood and adolescence than during adulthood (10). In the Finnish cohort for 1966, no relation was evident at 14 y, as was similarly shown in the British longitudinal studies, at least in boys at ages 7, 11, and 16 y (29).

Mothers and their offspring from higher social classes had normal body weight more often than did those from lower social classes. During childhood and adolescence, the manner of living and concerns of suitable body image are learned in a societal context (9, 35). These features are typical for each social class and the risk of behavior damaging health is higher in lower socioeconomic groups (32). Negative attitudes toward obesity and negatively correlated perceived weight and body satisfaction are observed among girls and women but less so or not at all among boys and men (9). Societal pressure for thinness is higher among higher social classes. Low-birth-weight children from low social classes are thus predisposed by biological and environmental factors to the development of overweight and obesity.

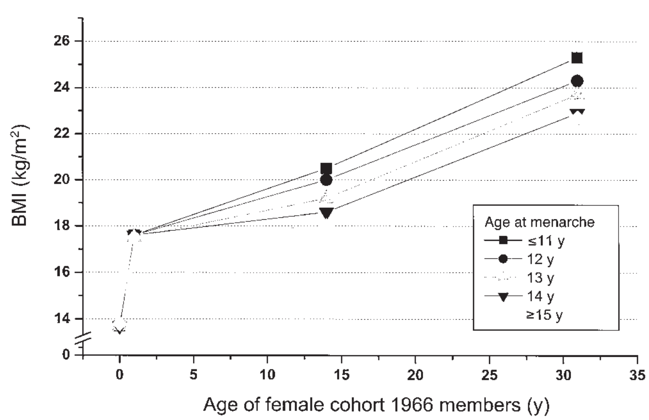

FIGURE 1. Body mass index (BMI) of female members of the northern Finland birth cohort for 1966 from birth to age 31 y by the age at menarche. At 14 and 31 y, the global P value was < 0.001 by analyses of variance. The number of females commencing menstruation at 11 y was 339, at 12 y was 898, at 13 y was 1083, at 14 y was 584, and at ≥15 y was 388.

Early maturation predicted overweight and obesity in adulthood in the present study, as in earlier studies (2, 36). However, no differences in BMI at birth or at 1 y were observed in relation to the age at menarche; thus, BMI during infancy was not associated with the age at menarche. The lack of an association between the age at menarche and BMI at birth and at 1 y suggests that factors occurring at a later stage of childhood may affect the age at menarche. Cooper et al (37) observed that girls who reached menarche at the youngest age had low birth weight but grew rapidly in childhood (during the first 7 y). The association between early maturation and adulthood obesity is probably multifactorial, partly determined by endocrine factors that promote the accumulation of body fat (38) and partly by behavioral factors. Late maturers have been described to be physically more active than early maturers (39), and the differences in energy intake and expenditure between early and late maturers during adolescence and adulthood are important. Early puberty may cause problems with identity; those undergoing puberty early may also psychologically mature earlier than girls of the same age without menarche. Among friends of the same age, the stress due to differences in appearance and in behavior between early and late maturers may lead early maturers to assume eating habits that predispose them to obesity in adulthood. This remains to be assessed.

Our study provided further evidence of maternal-offspring relations concerning body size (15, 16, 21). It also verified the increased risk of adult obesity among those who are fatter in childhood and adolescence (2–4, 11, 21, 40, 41). The mother's weight before pregnancy predicted the BMI of her offspring in all social groups. The heavier the mother, the heavier the offspring from birth to 31 y. This replicates the earlier findings of other longitudinal studies, which reported that children of obese parents are at increased risk of obesity throughout childhood and early adult life (15, 16, 42). With regard to child-adult continuities in BMI, BMI at 14 y predicted obesity in adulthood better than did birth weight or BMI at 1 y. This observation was similar to the earlier findings reviewed by Serdula et al (4), whereby the risk of becoming an obese adult was found to be greater among children who were obese at or around puberty. Thus, children who are obese near or at puberty form a special high-risk group that should be targeted for obesity prevention.

In conclusion, differences in BMI and in the prevalence of obesity in adulthood between social classes appear to be formed at least partly during early childhood. In addition to the low social class of the child's family, a high maternal BMI before pregnancy, the individual's own high BMI during adolescence, and early maturation (as measured by the age at menarche) are predictors of overweight and obesity in adulthood. Persons with the above-mentioned background factors form specific high-risk groups for obesity prevention.

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