Socioeconomic differences in weight gain and determinants and consequences of coronary risk factors[1–3]

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ABSTRACT

Background: The increasing prevalence of overweight and obesity is a major public health concern in many developed countries.
Objective: We aimed to describe socioeconomic differences in change in body mass index (BMI; in kg/m^2) from age 25 y, assess possible factors behind these differences, and study whether socioeconomic differences in a variety of coronary risk factors can be accounted for by change in BMI.
Design: The data come from a cohort study of London-based civil servants (Whitehall II), who participated in the first (1985–1988) and third (1991–1993) phases of the study and were 35–55-y old at phase 1; altogether there were 5507 men and 2466 women. Both study phases included a questionnaire and a screening examination.
Results: In men and women, employment grade—the measure of socioeconomic status used in this cohort—was strongly related to BMI gain from age 25 y to phase 3 (25 y apart on average). The lower the grade the larger the gain in BMI. Adjustment for health behaviors reduced the grade differences in BMI gain by ≈20%. A substantial part of the grade differences in diastolic and systolic blood pressure and plasma triacylglycerol concentrations could be accounted for by BMI change from age 25 y.
Conclusions: Grade differences in BMI change are evident, but many of the determinants of these differences remain unknown. If lower-status persons continue to gain weight more rapidly than higher-status persons, overweight is likely to be of growing importance as a pathway to social inequalities in ill health. *Am J Clin Nutr* 1999;69:719–26.

KEY WORDS Weight gain, body mass index, socioeconomic status, coronary risk factors, London civil servants, overweight

INTRODUCTION

Overweight has been related to physical functioning (1), coronary risk factors (2–8), coronary disease (9–12), and mortality (13–15). The increasing prevalence of overweight and obesity is a major public health problem in industrialized countries, especially in lower socioeconomic groups (16–18). Overweight in middle age is likely to represent the cumulative effects of gradual increases in weight from early adulthood.

It is therefore important to investigate the extent of socioeconomic differences in weight gain and the possible behavioral and psychosocial predictors of these changes (19). In addition, because at least some part of the effects of obesity on coronary heart disease are mediated by other more proximate risk factors such as blood pressure and lipid profiles (8), more detailed longitudinal evidence on the contribution of weight change to socioeconomic differences in these risk factors is needed.

The specific aims of the present study were to evaluate socioeconomic differences in body mass index (BMI) change from the age of 25 y, to assess the psychosocial and behavioral determinants of any differences in change, and to study whether socioeconomic differences in blood pressure and HDL-cholesterol and triacylglycerol concentrations can be accounted for by BMI and BMI change.

SUBJECTS AND METHODS

The data come from the Whitehall II study, a prospective cohort study of men and women aged 35–55 y who were working in the London offices of 20 civil service departments at enrollment. Subjects were invited to participate by letter. The overall response rate was 73%, although the true response rate is likely to be higher because ≈4% of those listed as employees were not eligible because they had moved before the study began. Altogether, 10 308 men and women responded and subsequently completed a self-administered health questionnaire and attended an extensive screening examination in 1985–1988. The data and the measurements are described more fully elsewhere

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(20). After initial participation in phase 1, a questionnaire was mailed in 1989 (phase 2) and in 1991–1993 (phase 3), when an additional screening examination also took place.

The population examined in the present study consists of those men and women who participated in phase 3 of the study and were 35–55-y old at phase 1: 5507 men and 2466 women. BMI, a measure of overall or generalized obesity, is the ratio of weight to height squared (kg/m^2). At phase 3, weight and height were measured at the screening examination. BMI at age 25 y was based on height at the time of the phase 1 screening and self-reported recall of weight at 25 y, as reported on the phase 1 questionnaire. Waist-to-hip circumference ratio, a measure of abdominal obesity, was based on measurement at the phase 3 screening.

Grade of employment at baseline (phase 1) was obtained by asking all participants for their civil service grade title. Three grades were compiled on the basis of this information: administrative (I), professional and executive (II), and clerical and office support (III). These grades differ markedly in salary: from an annual salary in 1987 of ≈£3000 to £6000 in grade III to ≈£18 000 to £62 000 in grade I. The grades also differ with respect to educational qualifications, housing tenure, and car ownership.

In addition, we used questionnaire-based self-reports of 4 health-related behaviors. Questions on current smoking, ever smoking, and number of manufactured cigarettes smoked daily were combined to derive a tobacco smoking variable with the following categories: "never smoker," "ex smoker," "light smoker" (1–10 cigarettes/d), "medium smoker" (11–20 cigarettes/d), and "heavy smoker" (≥21 cigarettes/d). Alcohol consumption was assessed with 2 variables: frequency of drinking in the past year (6 categories ranging from "no" to "twice a day or more") and a derived variable of number of units of alcohol (drinks of beer, wine, or spirits) consumed in the past week obtained from questions on quantities of spirits, wine, and beer consumed. An assessment of diet was based on 4 questions on the frequency of eating *1*) fish, *2*) fruit and vegetables, and the type of *3*) bread and *4*) milk usually consumed. From these data a 5-point score reflecting healthful aspects of the diet was compiled (5 = consume fruit and vegetables daily, fish weekly, and usually consume skim or low-fat milk and whole-meal bread; 1 = diet poor in all 4 respects). Physical activity was assessed with questions on hours of mild, moderate, and vigorous activity undertaken each week. These were aggregated into the following 3 categories: light, moderate (>1 h moderate physical activity/wk), and vigorous (>1 h vigorous physical activity/wk).

Job decision latitude or job control, a measure combining work decision authority and skill discretion, was based on the Karasek framework (21–23). Equal weights were given to 15 questions to create the scores. The 8 questions and statements on decision authority were as follows: "Do you have a choice in deciding how you do your job?", "Do you have a choice in deciding what you do at work?", "Others take decisions concerning my work.", "I have a good deal of say in decisions about work.", "I have a say in my own work speed.", "My working time can be flexible.", "I can decide when to take a break.", and "I have a great deal of say in planning my work environment. The 6 items for skill discretion were as follows: "Do you have to do the same things over and over again?", "Does your job provide you with a variety of interesting things?", "Is your job boring?", "Do you have the possibility of learning new things through your work?", and "Does your work demand a high level of skill or expertise?", "Does your job require you to take the initiative?" In addition, we measured the degree of control over one's health with 3 questions on whether the respondents believed that keeping healthy depended on things that the participants could do themselves, and whether they felt they could do things that reduced the risk of heart attack and cancer. Response alternatives for these questions and statements varied from often to never or not applicable.

At the phase 3 screening examination, blood pressure was measured twice with a Hawskley random-zero sphygmomanometer (Lynjay Services Limited, Worthing, United Kingdom). Blood was taken to determine the HDL and triacylglycerol concentrations. The techniques used were described elsewhere (24).

We used logistic regression, multinomial logistic regression, and linear regression to analyze the data (25, 26). The calculations were carried out with the GLIM (27) and STATA (28) software programs separately for each sex. The results were presented as means, differences in means, odds ratios and their 95% CIs. For odds ratios, the first category of each explanatory variable was taken as the reference group, with an odds ratio of 1.0.

RESULTS

Most of the men in the present study were employed in grade I (39%) and grade II (53%) jobs. The most common grades for women were grades II (42%) and III (45%). The mean BMI of men at phase 3 was 25.14; the mean waist-to-hip ratio was 0.903. The corresponding means were 25.72 and 0.776 for women. Civil service employment grade was strongly related to BMI and waist-to-hip ratio (**Table 1**). For men in grade III, age-adjusted odds of being above the 80th percentile of BMI and waist-to-hip ratio were 1.39 and 2.51, respectively; for women the corresponding figures were 1.72 and 2.21. The age-adjusted standardized differences in mean BMI and waist-to-hip ratio by grade are shown in Table 1. These means also show that among men examined in this study, grade differences in waist-to-hip ratio were larger than those for BMI. In women, grade differences in standardized means were similar for both BMI and waist-to-hip ratio.

By the time of the third phase of the Whitehall II study, men had had average gains in BMI of 2.52 and women of 3.74 (**Table 2**), corresponding to a weight increase of 7.8 kg in men and 9.3 kg in women. Grade differences in BMI at age 25 y were small among women and even smaller among men. However, BMI gain was more rapid at the lower end of the social spectrum. With adjustments for age, duration of follow-up, and BMI at age 25 y, the change in BMI was 0.37 more in grade II than in grade I men. In women, the corresponding adjusted difference in change in BMI was 1.19.

However, these average changes give an incomplete picture. Thus, in **Figure 1** are the adjusted multinomial odds ratios by grade of experiencing declining BMI: an increase in BMI of 3–6 or an increase of >6 in relation to a modest increase of <3. The largest grade differences in men and women were observed in those with the largest increases in body mass. Men in grade III were 2.5 times more likely to have had a gain in BMI of ≥6; for women the odds ratio was 2.8. No grade differences for declining BMI existed in women, but there was some indication that grade III men were more likely to experience a decline in BMI than grade I men.

Because the determinants of weight gain or body mass gain are different from those of weight decline, and because the main

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TABLE 1
Means and odds of being above the 80th percentile of waist-to-hip ratio and BMI and their 95% CIs by grade in Whitehall II men and women[1]

	Waist-to-hip ratio			BMI		
Sex and grade	Mean	Age adjusted difference in standardized mean[2]	Odds ratio	Mean	Age adjusted difference in standardized mean[2]	Odds ratio
Men						
Grade I (*n* = 2170)	0.899 (0.897, 0.902)	0 —	1.00 —	25.03 (24.90, 25.16)	0 —	1.00 —
Grade II (*n* = 2909)	0.904 (0.902, 0.906)	0.16 (0.11, 0.22)	1.47 (1.26, 1.71)	25.17 (25.06, 25.29)	0.07 (0.02, 0.13)	1.12 (0.97, 1.30)
Grade III (*n* = 428)	0.921 (0.915, 0.928)	0.40 (0.30, 0.50)	2.51 (1.97, 3.20)	25.49 (25.12, 25.86)	0.16 (0.06, 0.27)	1.39 (1.08, 1.80)
All (*n* = 5507)	0.903 (0.902, 0.905)	—	—	25.14 (25.06, 25.22)	—	—
Women						
Grade I (*n* = 310)	0.758 (0.750, 0.765)	0 —	1.00 —	24.52 (24.03, 25.00)	0 —	1.00 —
Grade II (*n* = 1035)	0.764 (0.760, 0.769)	0.06 (−0.06, 0.19)	1.42 (0.95, 2.11)	25.26 (24.98, 25.55)	0.14 (0.02, 0.27)	1.19 (0.82, 1.71)
Grade III (*n* = 1121)	0.792 (0.788, 0.796)	0.38 (0.25, 0.50)	2.21 (1.50, 3.26)	26.48 (26.20, 26.76)	0.35 (0.22, 0.48)	1.72 (1.21, 2.47)
All (*n* = 2466)	0.776 (0.773, 0.779)	—	—	25.72 (25.54, 25.91)	—	—

[1]95% CIs in parentheses. Grade I is administrative, grade II is professional and executive, and grade III is clerical. Grade I is the reference group for the analyses.
[2]Standardized means for waist-to-hip ratio and BMI were calculated from transformed data point values; the transformation was done by subtracting the mean from the original data point and dividing the result by 1 SD. Standardization was carried out separately for men and women.

TABLE 2
Mean weight and BMI (in kg/m^2) at age 25 y and at phase 3, mean BMI change, and adjusted difference in mean BMI change by grade in Whitehall II men and women[1]

	Characteristics at age 25 y		Characteristics at phase 3		BMI change from age 25 y to phase 3	
Sex and grade	Weight	BMI	Weight	BMI	Change	Adjusted difference in mean change[2]
	kg		*kg*			
Men						
Grade I (*n* = 2189)	71.27 (70.90, 71.64)	22.64 (22.54, 22.75)	78.71 (78.26, 79.16)	25.02 (24.89, 25.15)	2.38 (2.28, 2.47)	0 —
Grade II (*n* = 2879)	70.08 (69.73, 70.43)	22.55 (22.45, 22.64)	78.17 (77.76, 78.59)	25.16 (25.05, 25.28)	2.62 (2.52, 2.71)	0.27 (0.13, 0.41)
Grade III (*n* = 393)	68.28 (67.18, 69.37)	22.78 (22.44, 23.12)	76.15 (74.88, 77.43)	25.46 (25.07, 25.84)	2.67 (2.36, 2.98)	0.37 (0.11, 0.63)
All (*n* = 5461)	70.43 (70.18, 70.68)	22.60 (22.53, 22.67)	78.24 (77.94, 78.54)	25.13 (25.04, 25.21)	2.52 (2.46, 2.59)	—
Women						
Grade I (*n* = 308)	58.97 (58.12, 59.82)	21.63 (21.34, 21.92)	66.45 (65.11,67.80)	24.54 (24.05, 25.03)	2.91 (2.55, 3.27)	0 —
Grade II (*n* = 1027)	58.41 (57.83, 58.99)	21.88 (21.68, 22.07)	66.95 (66.16, 67.73)	25.27 (24.99, 25.56)	3.40 (3.17, 3.62)	0.46 (−0.01, 0.93)
Grade III (*n* = 1089)	57.38 (56.83, 57.93)	22.16 (21.96, 22.36)	67.93 (67.18, 68.69)	26.45 (26.17, 26.73)	4.29 (4.06, 4.52)	1.19 (0.72, 1.66)
All (*n* = 2424)	58.02 (57.65, 58.38)	21.97 (21.84, 22.10)	67.33 (66.82, 67.83)	25.71 (25.52, 25.90)	3.74 (3.59, 3.88)	—

[1]95% CIs in parentheses. Grade I is administrative, grade II is professional and executive, and grade III is clerical. Grade I is the reference group for analyses.
[2]Adjusted for age, duration of follow-up, and BMI based on recalled weight at age 25 y; the time from age 25 y to phase 3 has been on average 24.23 and 25.21 y for men and women, respectively.

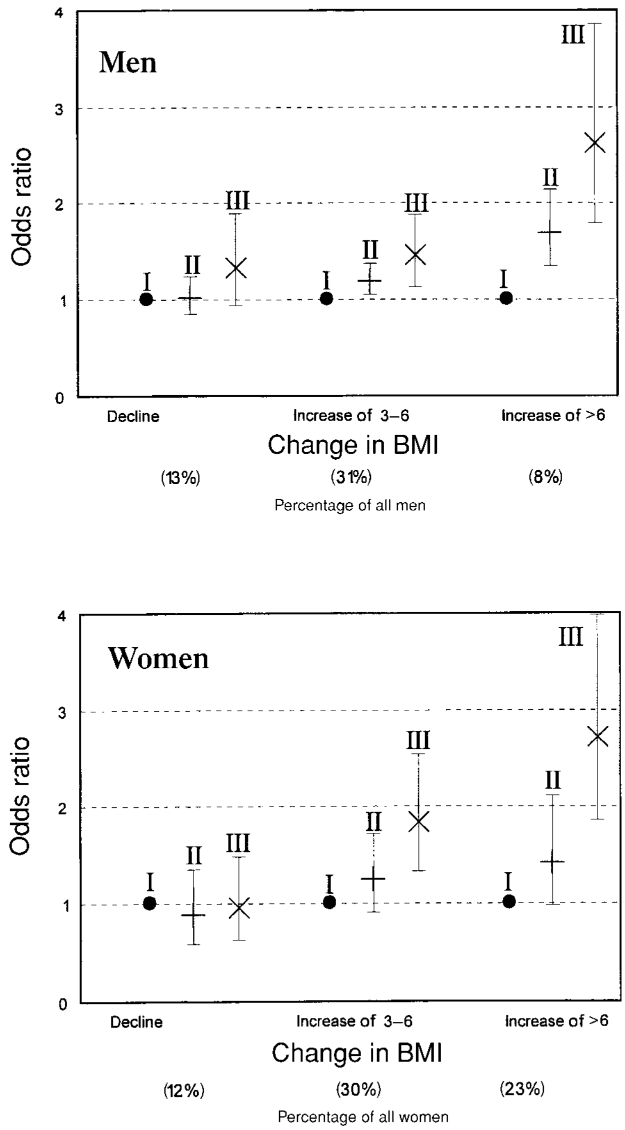

FIGURE 1. Odds ratios of change in BMI from age 25 y to phase 3 (≈25 y later) in Whitehall II men and women adjusted for age, duration of follow-up, and BMI at age 25 y, and 95% CIs by grade (grade I is administrative, grade II is professional and executive, and grade III is clerical; grade I is the reference group). BMI change is in relation to those with a BMI change of between 0 and 3.

interest of the present study was to analyze the determinants of grade differences in BMI gain, only results for participants with constant or increasing weight are shown in **Tables 3** and **4**. Grade III men had an odds ratio of 1.80 of experiencing a BMI gain of >3 as compared with grade I men; for women the corresponding odds ratio was 2.18. Alcohol consumption was negatively related to BMI gain in women. However, in men the relation was much weaker, although regular consumers of alcohol seemed to experience a larger gain in BMI. Smoking was also related to BMI; male smokers and exsmokers were more likely to gain body mass, whereas women in these same groups were more likely to experience a decline in BMI. Additional analyses not presented here indicate that part of the weight gain in male smokers was associated with their low employment grade and patterns of alcohol consumption.

Men and women who participated in moderate and vigorous activity and reported consuming a better diet were less likely to experience an increase in body mass. Men who took part in vigorous activity had an odds ratio of 0.61 of having a BMI gain of >3. The corresponding odds ratio was 0.67 for women. There was also evidence that health control and decision latitude at work were related to body mass gain.

In men, separate adjustment for physical activity and diet accounted for ≈15–20% of the grade differences in the odds ratio of having a BMI gain of >3 (Table 4). Adjustment for other explanatory variables did not make a major contribution. Overall, ≈20% of the grade differences could be accounted for. Similar results were obtained for gain in mean BMI from age 25 y (results not shown here).

In women, grade differences in odds ratios of BMI gain could only be accounted for by including alcohol consumption in the logistic regression analyses. Adjusting for all other explanatory variables simultaneously made no additional contribution. However, grade differences in mean BMI gain among women could be partly accounted for by physical activity and alcohol consumption (≈20% each), and the model that included all explanatory variables accounted for about one-third of the grade differences (results not shown here).

Lower-grade men and women (grades II and III) were more likely to have high diastolic and systolic blood pressure, as well as low plasma HDL-cholesterol and high triacylglycerol concentrations at phase 3 than grade I men and women (**Table 5**). Further analyses not presented here also suggested that both BMI at age 25 y and, in particular, change in BMI from age 25 y to phase 3 were strong predictors of these 4 risk factors.

In men and women, ≈50–75% of the small diastolic and systolic blood pressure differences between grades I and III could be accounted for by BMI at age 25 y and subsequent BMI change. The contribution of BMI change was especially relevant. Men had relatively small grade differences in HDL. However, in women these differences were large and could not be accounted for by grade differences in BMI at age 25 y or BMI change. Grade differences in plasma triacylglycerol concentrations were large in both men and women, and adjustment for BMI change reduced these differences by about one-third in men and by about one-half in women. Additional analyses suggested that to a large extent, the contribution of BMI change to grade differences in diastolic and systolic blood pressure, as well as triacylglycerol concentrations, was independent of other behavioral risk factors.

DISCUSSION

For both men and women, employment grade, the measure of socioeconomic status used in the present study, was strongly related to waist-to-hip ratio and BMI. In men, but not in women, grade differences were larger for waist-to-hip ratio than for BMI. Waist-to-hip ratio, a measure of abdominal obesity, may be a biologically relevant predictor of coronary heart disease because it has been closely related to blood pressure, lipid profiles, and glucose concentrations (29).

In the present study, BMI gain from age 25 y to phase 3 (≈25 y later) was considerable. On average, the BMI gain was ≈2.5 in men and 3.7 in women, corresponding to a mean weight gain of 7.8 kg in men and 9.3 kg in women. BMI gain was strongly related to grade in men and especially so in women; lower grades

TABLE 3
Age-adjusted odds ratios of having a gain in BMI (in kg/m^2) of > 3 in comparison with those having a BMI gain of 0–3 according to explanatory variables for Whitehall II men and women[1]

Explanatory variable	Body mass index: Men	Body mass index: Women
Employment grade[2]		
Grade I	1.00 [1617]	1.00 [229]
Grade II	1.32 (1.15, 1.51) [2208]	1.26 (0.93, 1.72) [749]
Grade III	1.80 (1.37, 2.36) [266]	2.18 (1.59, 2.99) [805]
Alcohol units consumed in the last week[3]		
None	1.00 [470]	1.00 [481]
Moderate	0.87 (0.71, 1.07) [2403]	0.87 (0.69, 1.10)[1001]
Heavy	1.18 (0.95, 1.47) [1218]	0.63 (0.46, 0.86) [301]
Alcohol consumed in the past year		
Seldom or never	1.00 [894]	1.00 [781]
1–2 times/wk	0.90 (0.76, 1.06) [1757]	0.71 (0.57, 0.89) [626]
Daily	1.10 (0.92, 1.30) [1440]	0.64 (0.49, 0.83) [376]
Smoking		
Never smoker	1.00 [2013]	1.00 [1026]
Exsmoker	1.40 (1.22, 1.61) [1566]	0.88 (0.69, 1.12) [431]
Smoker	1.49 (1.22, 1.82) [512]	0.79 (0.61, 1.03) [326]
Physical activity		
Light	1.00 [402]	1.00 [486]
Moderate	0.74 (0.59, 0.93) [1506]	0.69 (0.54, 0.88) [821]
Vigorous	0.61 (0.49, 0.76) [2183]	0.67 (0.51, 0.89) [476]
Diet[4]		
Poor	1.00 [2532]	1.00 [991]
Good	0.73 (0.64, 0.84) [1559]	0.83 (0.68, 1.02) [792]
Health control		
Good	1.00 [2070]	1.00 [839]
Intermediate	1.14 (0.99, 1.30) [1590]	0.97 (0.79, 1.21) [704]
Poor	1.28 (1.03, 1.58) [431]	1.24 (0.91, 1.70) [240]
Decision latitude at work		
Good	1.00 [1150]	1.00 [233]
Intermediate	1.09 (0.93, 1.27) [1677]	1.26 (0.92, 1.75) [538]
Poor	1.22 (1.03, 1.44) [1264]	1.43 (1.05, 1.93)[1012]

[1]95% CIs in parenthesis; *n* in brackets. Analysis for those subjects whose BMI increased from age 25 y.
[2]Grade I is administrative, grade II is professional and executive, and grade III is clerical.
[3]For men "moderate" drinking is 1–15 units of alcohol/wk and "heavy" drinking >15 units/wk; for women these are 1–10 and > 10 units/wk.
[4]"Good" diet is having 3 or 4 of the total of 4 healthy aspects of diet (Methods).

TABLE 4
Contribution of different variables to grade differences in BMI (in kg/m^2) gain from age 25 y to phase 3 (≈25 y later) in Whitehall II men and women[1]

Variable	Men: Grade I (*n* = 1617)	Men: Grade II (*n* = 2208)	Men: Grade III (*n* = 266)	Women: Grade I (*n* = 229)	Women: Grade II (*n* = 749)	Women: Grade III (*n* = 805)
Age	1	1.32	1.80	1	1.26	2.18
Age + alcohol[2]	1	1.33	1.83	1	1.22	1.96
Age + smoking	1	1.28	1.73	1	1.29	2.26
Age + physical activity	1	1.30	1.61	1	1.25	2.07
Age + diet	1	1.26	1.63	1	1.27	2.20
Age + health control	1	1.33	1.77	1	1.28	2.19
Age + decision latitude at work	1	1.33	1.89	1	1.27	2.28
All variables	1	1.26	1.64	1	1.29	2.16
95% CI	—	(1.09, 1.47)	(1.19, 2.25)	—	(0.92, 1.81)	(1.45, 3.23)

[1]Analysis was for subjects whose BMI increased from age 25 y. Adjusted odds ratios of having a gain in BMI of >3 in comparison with those having a gain in BMI of 0–3; adjustment was not carried out with the truncated variables presented in Table 3, but with the original variables as described in Methods. Grade I is administrative, grade II is professional and executive, and grade III is clerical. Grade I is the reference group for the analyses.
[2]Adjusted for both alcohol units consumed during the past week and frequency of alcohol consumption in the past year.

TABLE 5
Adjusted odds ratios of being above the 80th percentile of selected biological risk factors by grade in Whitehall II men and women[1]

	Men			Women		
Risk factors and adjusted variables	Grade I	Grade II	Grade III	Grade I	Grade II	Grade III
Diastolic blood pressure						
Age[2]	1	0.99	1.18	1	1.31	1.29
Age + BMI at age 25 y[3]	1	1.00	1.16	1	1.30	1.26
Age + BMI at age 25 y + BMI change[4]	1	0.93	1.04	1	1.23	1.07
95% CI	—	(0.80, 1.08)	(0.78, 1.38)	—	(0.84, 1.81)	(0.73, 1.58)
Systolic blood pressure						
Age	1	0.99	1.16	1	1.17	1.28
Age + BMI at age 25 y	1	0.99	1.14	1	1.14	1.23
Age + BMI at age 25 y + BMI change	1	0.95	1.06	1	1.08	1.08
95% CI	—	(0.81, 1.11)	(0.80, 1.40)	—	(0.73, 1.59)	(0.74, 1.59)
HDL cholesterol						
Age	1	0.96	0.87	1	0.49	0.33
Age + BMI at age 25 y	1	0.95	0.87	1	0.49	0.34
Age + BMI at age 25 y + BMI change	1	1.01	0.91	1	0.52	0.40
95% CI	—	(0.87, 1.18)	(0.68, 1.21)	—	(0.38, 0.71)	(0.29, 0.55)
Triacylglycerol						
Age	1	1.34	1.54	1	1.52	2.01
Age + BMI at age 25 y	1	1.34	1.52	1	1.49	1.94
Age + BMI at age 25 y + BMI change	1	1.26	1.36	1	1.41	1.64
95% CI	—	(1.08, 1.47)	(1.02, 1.80)	—	(0.93, 2.15)	(1.09, 2.48)

[1] Grade I is administrative, grade II is professional and executive, and grade III is clerical. Grade I is the reference group for the analyses.
[2] Adjusted for age.
[3] Adjusted for age and BMI at age 25 y.
[4] Adjusted for age, BMI at age 25 y, and BMI change between age 25 y and phase 3 (≈25 y later).

gained considerably more weight than higher grades. Clearly, the major determinant of grade differences in BMI in middle age was not BMI in young adulthood but weight gain since that age.

Although we were able to identify several behavioral and psychosocial determinants of weight gain, only a part of the grade differences in weight gain could be attributed to these factors. Adjustment for health-related behaviors, ie, tobacco and alcohol consumption, physical activity, and diet, reduced the mean grade differences in BMI gain by ≈20–25% in men and women. Similar reductions were observed in grade differences in BMI gain of >3 in men but not in women. Overall, the great majority of grade differences in BMI gain cannot be understood in terms of the explanatory variables in these data. In part, this may be an indication of inaccurate measurement of the behavioral and psychosocial determinants of weight change analyzed in the present study. First, we were only able to measure our determinants of weight gain once, although the period over which weight gain occurred was on average 25 y. Second, our measures of the determinants of weight gain may be imperfect. For example, we may have underestimated the relevance of physical activity as well as diet, both of which are complex individual behavioral characteristics. Further analyses of the determinants of weight gain and socioeconomic differences in weight gain also need to explore other sociodemographic and psychosocial determinants. A potentially interesting area for research is marital situation and family life. Furthermore, it is likely that the long-term process of weight gain from young adulthood may be more related to poor cognitive control over weight and perceptions of one's body, and lack of motivation to remain slim.

In men, grade was modestly related to systolic and diastolic blood pressure and HDL cholesterol and more strongly related to triacylglycerol concentrations at phase 3. In women, all these grade differentials were stronger; age-adjusted odds ratios of being above the 80th percentile of HDL-cholesterol and triacylglycerol concentrations were 0.33 and 2.01, respectively. In both men and women, the grade differences in biological risk factors analyzed in this study could not be accounted for by grade differences in BMI at age 25 y. This is a reflection of the small grade differences in BMI at that age. However, part of the grade differences in diastolic and systolic blood pressure and plasma triacylglycerol concentrations at phase 3 could be accounted for by BMI change from age 25 y. Grade differences in HDL cholesterol were not due to differences in BMI or BMI change. However, rather than emphasizing the importance of BMI change from age 25 y to phase 3 (while adjusting for BMI at age 25 y), it may be more appropriate to focus on current weight at phase 3. These 2 ways of presenting the data are identical in terms of the statistical model and both emphasize the significance of experiences in later adulthood after the age of 25 y.

A social gradient in coronary heart disease is well established (30–32), and obesity has been related to coronary heart disease in several large studies (9–12). However, there is little direct evidence of the contribution of weight and obesity to social differences in coronary disease. Overall, about one-quarter to one-half of the social differences in coronary disease can be explained by known risk factors (32–34). The results obtained in the present study indicate that the contribution of obesity may be mediated through some of these risk factors, ie, blood pressure and triacylglycerol concentrations. At the same time, grade differences in obesity and weight change may be important determinants of grade differences in morbidity from other diseases and physical functioning.

In the interpretation of our findings, attention needs to be paid to specific aspects of our data. The baseline (phase 1) retrospective question on weight at age 25 y referred to a period that was well before the measurement of other explanatory factors. It can therefore plausibly be argued that weight gain from age 25 y is not determined by grade but that weight gain determines grade (35–38). In societies that emphasize leanness, especially in women, social achievement and advancement may be conditioned by considerations of visible appearance. The evidence for the independent effects of obesity on social achievement usually come from relatively severely obese subjects (36, 39–40). Analyses of data from the present study show that the greatest grade differences in BMI gain occurred in the 2 lowest tertiles of BMI at age 25 y. In addition, grade differences in BMI gain that occurred for those with BMIs <30 are almost the same as those observed for the total study population; only the difference between grade I and grade III is underestimated by $\approx$20–40% (results not shown here). Thus, it seems that at least in this study population, most of the weight gain took place in a range of BMI in which the physical effects of weight gain may be less visible and accordingly less relevant for social achievement. However, the large grade differences observed in the largest gains in body mass could still partly be attributed to causality operating from weight gain to grade.

For the cohort examined in this study, weight at age 25 y was obtained retrospectively at the baseline questionnaire. This source of information may have been imprecise because of the possibility of recall bias and underreporting of overweight, a phenomenon observed in earlier studies on analyses of current weight (41). If, in the present study, such a tendency to report ideal rather than actual weight were not related to grade but only to the degree of overweight, it would lead to *1*) an underestimation of weight and grade differences in weight at age 25 y, and *2*) an overestimation of weight change and grade differences in weight change. However, previous studies indicated that socioeconomic differences in weight do not seem to be pronounced in childhood but emerge later in early adulthood (42, 43). The relatively small grade differences in BMI at age 25 y that were observed in the present study may thus be what we would have expected. Furthermore, analyses of measured and self-reported current weight at baseline (phase 1) show that the underestimation of weight in participants who had increases in weight from age 25 y was 0.7 kg in men and 1 kg in women. Socioeconomic differences in this bias were small. Thus, retrospective underreporting of weight does not seem to have been of crucial relevance to the main conclusions of the study.

In summary, grade differences in BMI and gain in BMI from age 25 y are evident but many of the determinants of these differences remain to be uncovered. The present study has shown that grade differences in weight change are important predictors of grade differences in blood pressure and triacylglycerol concentrations in men and especially in women. If lower-status individuals continue to gain weight more rapidly than higher status individuals, overweight is likely to be of growing importance as a pathway to social inequalities in ill health.

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