RESEARCH REPORT

Central and total obesity in middle aged men and women in relation to lifetime socioeconomic status: evidence from a national birth cohort

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Study objective: To investigate the influence of social class in childhood, young adulthood and middle age, and intergenerational mobility, on adult central and total obesity.

Design: Prospective, population based, birth cohort study.

Participants and Setting: 1472 men and 1563 women born in 1946 in England, Scotland, and Wales.

Outcome measures: Waist-hip ratio, waist-height ratio, waist circumference, and body mass index at age 53 years.

Main results: Father's social class at participant's age 4 years was inversely associated with adult central and total obesity at age 53 years in men and women. For example, the mean difference of waist-hip ratio (95% confidence intervals) between father's professional social class I and unskilled manual social class V was 2.6% (0.7 to 4.6) for men and 2.5% (0.5 to 4.4) for women. The effect of father's social class remained after adjustment for participant's own social class in young adulthood and middle age. Both adult social classes were inversely related to obesity among women, but not men, after adjustment for childhood circumstances. Upwardly mobile men and women were less obese than participants remaining in their father's social class and their levels of obesity tended to be between the class they left and the class they joined.

Conclusions: The effect of social class on adult obesity differed according to the stage in the life course at which social class was measured, and gender. Childhood circumstances had enduring influences on adult obesity, although our results on intergenerational mobility indicate potential reversibility of early life disadvantage.

Mean levels of obesity have increased in industrialised countries and are associated with many leading causes of death.¹ Total obesity and centralisation of fat influence the risk of diabetes, cardiovascular morbidity and premature death.^{2–6} Waist-hip ratio, waist-height ratio, and waist circumference are estimates for the amount of (excess) visceral fat and are strong predictors of coronary heart disease and related risk factors.⁷

Lower childhood and adult social class have both been associated with higher levels of adult obesity.^{8–15} Surprisingly few studies have tried to differentiate the effects of early and adult social class on adult obesity,^{16–20} or investigated the effect of intergenerational social mobility.^{21–22} None of these studies used prospective measures of childhood social class or attempted to separate the effects of social class at more than two time points. The only study to include both men and women was unrepresentative of the general population,¹⁸ and only two studies considered measures of central obesity.^{16–18} Questions remain regarding the cumulative influence of lifetime socioeconomic circumstances, the relative influence of early and later life socioeconomic circumstances, and the effect of intergenerational social mobility on adult obesity.

The MRC National Survey of Health and Development is a large UK cohort study of men and women who have been followed up since their birth in March 1946 with prospectively collected data on social class from childhood to adult life. This paper extends our earlier study¹⁰ by examining the effect of all six social classes in childhood, young adult life and midlife on central and total obesity at age 53 years. Firstly, we ask whether childhood social class had additional

effects on central and total obesity at age 53 years once the effects of social class at ages 26 and 43 years were accounted for (and vice versa). Are these effects similar for central and total obesity and do they show the same trend in men and women? Secondly, we ask whether levels of central and total obesity are modified by intergenerational mobility? Does the effect of mobility on obesity depend on father's social class and the extent of upward social mobility?

METHODS

Participants

The Medical Research Council's national survey of health and development (NSHD) is a prospective birth cohort study, consisting of a class stratified sample of a third (5362 births; 2547 women, 2815 men) of all births, that occurred in the first week of March 1946 in England, Scotland, and Wales. Follow up included 21 contacts with the whole cohort from birth to the most recent, when survey members were 53 years of age and 3035 participants (1472 men, 1563 women) provided information and the majority (2989) were interviewed and examined by research nurses at home. Where it was inconvenient for the study member to have a home visit, participants completed a postal questionnaire (n = 46). This corresponds to a participation rate of 70.5% among survivors still resident in England, Wales, or Scotland and 89.6% for whom contact was attempted. Contact was not attempted for people who had previously refused to take part (648), were living abroad (583), were untraced since last contact at 43 years (266) or had already died (476). The population contacted was still in most respects representative of the original cohort.²³

Anthropometric variables

At age 53 years measures of weight (kg), height (cm), waist (cm) and hip circumference (cm) were obtained according to a standardised protocol. Weight was measured to the nearest 0.1 kg with participants wearing light indoor clothing and no shoes. Height was measured to the nearest 0.5 cm, using a portable stadiometer with participants standing without shoes and heels against the wall as tall as possible with the head in the Frankfort plane. Waist circumference was measured at a point midway between the costal margin and the iliac crest and in line with the mid-axilla. To measure hip circumference the greater trochanter was located as the widest part of the hips at the level of the buttock line. In each case, the tape was pulled taut and a measurement to the nearest 1 mm was taken in mid-expiration with study members standing straight with feet together, arms hanging loosely, and looking straight ahead. Waist-hip ratio (waist circumference (cm) divided by hip circumference (cm)) and waist-height ratio (waist circumference (cm) divided by height (cm)) were expressed as a percentage. Body mass index (weight (kg) divided by squared height squared (m^2)) was used as a measure of total obesity.

Social class and mobility

Social class was based on occupation according to the registrar general's classification with six categories each (I professional, II intermediate, III skilled non-manual, IV skilled manual, V semi-skilled, V unskilled) for the three time points. Father's occupation was used as an indicator of childhood social class when survey members were 4 years old, or if not available, on his occupation when survey members were aged 7 years ($n = 125$). Social class at ages 26 and 43 years was based on the current or last occupation of the head of the household, using the convention of taking the male over the female occupation when both were employed.

Smoking and physical exercise are possible mediators of the influence of social class on obesity. At age 53 years participants provided information on smoking status, and "current" smokers were distinguished from "previous" and "never" smokers. Information on physical exercise was based on having taken part in any sports or vigorous leisure time activities or having done any exercise in their spare time (not including getting to and from work) in the past four weeks.

Statistical analysis

The highest social class was used as the reference category, and mean levels of obesity of all other classes were compared with this group. Regression models were used to test the relation between social class at each age, entered as a categorical variable, and each of the obesity measures. Analysis was restricted to participants with information on social class at each of the three time points. We also performed tests for trend to check whether levels of obesity increased linearly with decreasing social class. Multiple regression was used to assess the effect of social class at one time point adjusted for social class at both of the other points. There were statistically significant sex by social class interactions, indicating that the effects of social position at each time point on central and total obesity differed by sex. Consequently all analysis was undertaken separately for men and women and interactions are reported where relevant.

To investigate the effects of participants' upward mobility between father's and adult social class at 43 years on adult obesity, we aggregated the two highest (I and II) and two lowest (IV and V) social classes. We created a social mobility variable with six upwardly mobile categories and four categories representing those who were in the same social class at both time points. Further analysis showed that results from that model were robust when adjusted for smoking and exercise. Too few participants experienced downward inter-generational mobility to allow the investigation of this effect in such detail. A second social mobility variable was therefore created differentiating non-manual from manual occupations at each time point. For both mobility variables, tests were carried out to assess whether obesity varied across categories. Analyses were performed using the computer software Statistical Package for the Social Sciences.

RESULTS

Father's social class

Father's social class was inversely associated with all measures of obesity in men and women at age 53 years (table 1) These associations remained significant at the 5% level after adjustment for both adult social classes, with the exception of waist circumference in men (table 2) This difference between men and women was statistically significant ($p = 0.03$ for test for sex by social class interaction).

Table 1A Unadjusted results for men: mean obesity levels (95% confidence intervals) for professional social class 1 (reference group) and differences in means between each other social class and the reference group

Men		Waist-hip ratio (n = 1299)	Waist-height ratio (n = 1299)	Waist circumference (n = 1300)	Body mass index (n = 1299)
Father's social class	n*	$p \leq 0.001$ ($p \leq 0.001$ †)	$p \leq 0.001$ ($p \leq 0.001$ †)	$p = 0.02$ ($p = 0.04$ †)	$p \leq 0.001$ ($p \leq 0.001$ †)
I professional (reference group)	76	91.7 (90.3 to 93.1) %	53.9 (52.6 to 55.3) %	95.2 (92.8 to 97.6) cm	26.1 (25.2 to 27.0) kg/m^2
II intermediate	223	0.6 (−1.0 to 2.2)	0.9 (−0.7 to 2.5)	1.5 (−1.3 to 4.3)	0.7 (−0.3 to 1.7)
III skilled non-manual	239	1.4 (−0.2 to 3.0)	1.5 (0.0 to 3.1)	2.0 (−0.8 to 4.7)	0.9 (−0.1 to 1.9)
III skilled manual	393	3.4 (1.5 to 4.6)	3.1 (1.6 to 4.6)	3.9 (1.3 to 6.6)	1.9 (0.9 to 2.9)
IV semi-skilled	282	1.9 (0.3 to 3.4)	2.2 (0.6 to 3.7)	2.3 (−0.4 to 5.1)	1.3 (0.3 to 2.3)
V unskilled	86	2.6 (0.7 to 4.6)	2.8 (0.9 to 4.7)	2.4 (−0.9 to 5.7)	1.8 (0.5 to 3.0)
Adult social class at 26 years		$p = 0.002$ ($p \leq 0.001$ †)	$p = 0.02$ ($p = 0.002$ †)	$P = 0.4$ ($p = 0.3$ *)	$p = 0.05$ ($p = 0.03$ *)
I professional (reference group)	137	92.6 (91.5 to 93.6) %	55.0 (54.0 to 56.0) %	97.4 (95.6 to 99.2) cm	26.9 (26.3 to 27.6) kg/m^2
II intermediate	333	0.3 (−0.9 to 1.6)	0.5 (−0.7 to 1.8)	−0.3 (−2.4 to 1.9)	0.2 (−0.6 to 1.0)
III skilled non-manual	205	0.6 (−0.7 to 2.0)	0.4 (−0.9 to 1.7)	−0.3 (−2.6 to 2.1)	0.2 (−0.7 to 1.1)
III skilled manual	448	1.9 (0.7 to 3.1)	1.7 (0.5 to 2.9)	1.2 (−0.9 to 3.3)	0.9 (0.2 to 1.7)
IV semi-skilled	153	1.4 (−0.1 to 2.8)	1.2 (−0.2 to 2.7)	−0.2 (−2.7 to 2.3)	0.6 (−0.4 to 1.5)
V unskilled	23	1.6 (−1.1 to 4.4)	1.8 (−0.9 to 4.5)	0.0 (−4.7 to 4.8)	−0.3 (−2.0 to 1.5)
Adult social class at 43 years		$p \leq 0.001$ ($p \leq 0.001$ *)	$p = 0.02$ ($p = 0.002$ *)	$p = 0.3$ ($p = 0.09$ *)	$p = 0.1$ ($p = 0.2$ *)
I professional (reference group)	144	92.3 (91.3 to 93.3) %	54.7 (53.7 to 55.7) %	96.1 (94.3 to 97.8) cm	26.7 (26.1 to 27.4) kg/m^2
II intermediate	548	0.7 (−0.5 to 1.8)	1.0 (−0.2 to 2.1)	1.4 (−0.6 to 3.4)	0.6 (−0.2 to 1.3)
III skilled non-manual	119	1.7 (0.2 to 3.2)	1.5 (0.0 to 3.0)	2.0 (−0.6 to 4.6)	0.8 (−0.2 to 1.8)
III skilled manual	368	2.4 (1.2 to 3.6)	2.0 (0.8 to 3.2)	2.4 (0.4 to 4.5)	1.0 (0.2 to 1.7)
IV semi-skilled	98	1.7 (0.1 to 3.3)	1.8 (0.2 to 3.4)	1.9 (−0.9 to 4.7)	0.6 (−0.5 to 1.6)
V unskilled	22	3.0 (0.2 to 5.8)	0.6 (−2.1 to 3.4)	−0.1 (−4.9 to 4.7)	−0.6 (−2.5 to 1.2)

*Numbers are based on the model including waist-hip ratio and vary only slightly for the other obesity measures. †Test for trend.

Table 1B Unadjusted results for women: mean obesity levels (95% confidence intervals) for professional social class 1 (reference group) and differences in means between each other social class and the reference group

Women		Waist-hip ratio (n = 1345)	Waist-height ratio (n = 1342)	Waist circumference (n = 1347)	Body mass index (n = 1337)
Father's social class	n†	p ≤ 0.001 (p ≤ 0.001*)	p ≤ 0.001 (p ≤ 0.001*)	p ≤ 0.001 (p ≤ 0.001*)	p ≤ 0.001 (p ≤ 0.001*)
I professional (reference group)	86	79.5 (78.1 to 80.8) %	51.1 (49.4 to 52.8) %	83.6 (80.9 to 86.3) cm	26.5 (25.4 to 27.7) kg/m ²
II intermediate	228	0.1 (−1.5 to 1.7)	0.6 (−1.4 to 2.6)	0.4 (−0.8 to 3.5)	0.1 (−1.3 to 1.5)
III skilled non-manual	260	0.6 (−1.0 to 2.2)	−0.0 (−2.0 to 1.9)	−0.6 (−3.7 to 2.5)	−0.6 (−1.9 to 0.8)
III skilled manual	414	1.1 (−0.4 to 2.7)	2.7 (0.8 to 4.5)	2.8 (−0.2 to 5.7)	1.5 (0.3 to 2.8)
IV semi-skilled	273	2.2 (0.6 to 3.8)	4.3 (2.4 to 6.3)	5.4 (2.3 to 8.5)	2.1 (0.8 to 3.4)
V unskilled	84	2.5 (0.5 to 4.4)	3.6 (1.2 to 6.0)	3.6 (−0.3 to 7.4)	1.3 (−0.4 to 2.9)
Adult social class at 26 years		p ≤ 0.001 (p ≤ 0.001*)	p ≤ 0.001 (p ≤ 0.001*)	p ≤ 0.001 (p ≤ 0.001*)	p ≤ 0.001 (p ≤ 0.001*)
I professional (reference group)	131	79.2 (78.1 to 80.3) %	51.0 (49.6 to 52.4) %	83.15 (81.0 to 85.3) cm	26.4 (25.5 to 27.4) kg/m ²
II intermediate	360	0.1 (−1.2 to 1.4)	0.4 (−1.2 to 2.0)	0.5 (−2.0 to 3.1)	0.2 (−0.9 to 1.3)
III skilled non-manual	218	1.3 (−0.1 to 2.7)	1.8 (0.1 to 3.6)	2.3 (0.5 to 5.0)	0.8 (−0.4 to 2.0)
III skilled manual	411	1.8 (0.6 to 3.1)	2.9 (1.4 to 4.5)	3.3 (0.8 to 5.8)	1.4 (0.3 to 2.5)
IV semi-skilled	188	2.8 (1.4 to 4.3)	4.9 (3.1 to 6.6)	6.2 (3.3 to 9.0)	2.2 (1.0 to 3.5)
V unskilled	37	3.8 (1.5 to 6.1)	6.1 (3.2 to 9.0)	8.0 (3.4 to 12.7)	2.3 (0.3 to 4.3)
Adult social class at 43 years		p ≤ 0.001 (p ≤ 0.001*)	p ≤ 0.001 (p ≤ 0.001*)	p ≤ 0.001 (p ≤ 0.001*)	p ≤ 0.001 (p ≤ 0.001*)
I professional (reference group)	134	79.4 (78.3 to 80.5) %	51.5 (50.2 to 52.9) %	83.7 (81.5 to 85.8) cm	26.7 (25.7 to 27.6) kg/m ²
II intermediate	558	0.6 (−0.6 to 1.8)	0.5 (−1.0 to 2.0)	0.74 (−1.7 to 3.1)	0.2 (−0.8 to 1.3)
III skilled non-manual	152	1.0 (−0.5 to 2.5)	1.4 (−0.4 to 3.3)	1.85 (−1.1 to 4.8)	0.4 (−0.9 to 1.6)
III skilled manual	359	1.3 (0.0 to 2.6)	2.3 (0.7 to 3.9)	2.64 (0.1 to 5.2)	1.2 (0.1 to 2.3)
IV semi-skilled	115	4.6 (3.0 to 6.2)	5.4 (3.4 to 7.4)	7.53 (4.4 to 10.7)	2.5 (1.2 to 3.9)
V unskilled	27	2.4 (−0.3 to 5.1)	7.9 (4.6 to 11.2)	11.12 (5.9 to 16.4)	5.1 (2.8 to 7.4)

†Numbers are based on the model including waist-hip ratio and vary only slightly for the other obesity measures. *Test for trend.

Adult social class

In women, both adult social classes (at ages 26 and 43 years) were inversely associated with all obesity measures at age 53 years (table 1). After adjustment for all three measures of social class these associations remained for all but the relation between social class at 26 years and body mass index (table 2). By contrast in men, the associations observed in the unadjusted models between adult social class at ages 26 or 43 years and obesity (table 1) did not remain in the fully adjusted models, apart from a significant increasing trend in waist-hip ratio with decreasing social class at 43 years (table 2). There were significant sex differences in the effect of social class at 26 years on waist-height ratio ($p = 0.04$ for test for sex by social class interaction) and the effect of social class at 43 years on waist-hip ratio ($p = 0.01$), waist circumference ($p = 0.01$) and body mass index ($p = 0.001$), after adjustment for father's social class.

Social mobility

More cohort members experienced intergenerational upward social mobility (men 54.8%, women 55.2%) than downward social mobility (men 17.3%, women 19.9%) between father's social class and adult social class at 43 years. Over a quarter of men (27.9%) and women (24.9%) maintained their original social class. Mean levels of central and total obesity of the upwardly mobile, compared with those who stayed in the same class throughout their life course, are shown in table 3. There was significant variation in means across categories of this social mobility variable for all measures of obesity and for both men and women (table 3).

Among men and women who maintained their father's social class, those from social classes I and II had the lowest levels of all obesity measures. For example, the waist-hip ratio was 92.1% for men and 79.3% for women in these classes compared with 94.6% for men and 84.3% for women

Table 2A Adjusted results from multiple regression models including social class at all time points for men: differences in means (95% confidence intervals) between each social class and the professional social class 1 (reference group)

Men	Waist-hip ratio (%) (n = 1299)	Waist-height ratio (%) (n = 1299)	Waist circumference (cm) (n = 1300)	Body mass index (kg/m ²) (n = 1299)
Father's social class	p = 0.002 (p = 0.01)	p = 0.002 (p = 0.002*)	p = 0.06 (p = 0.1*)	p = 0.002 (p = 0.001*)
I professional (reference group)	0	0	0	0
II intermediate	0.3 (−1.3 to 1.9)	0.7 (−1.0 to 2.3)	1.3 (−1.6 to 4.1)	0.6 (−0.5 to 1.6)
III skilled non-manual	1.1 (−0.5 to 2.7)	1.3 (−0.3 to 2.9)	1.8 (−1.1 to 4.6)	0.8 (−0.2 to 1.9)
III skilled manual	2.3 (0.7 to 3.9)	2.6 (1.0 to 4.2)	3.6 (0.8 to 6.3)	1.7 (0.7 to 2.8)
IV semi-skilled	1.1 (−0.6 to 2.7)	1.6 (0.0 to 3.3)	2.0 (−0.9 to 4.8)	1.1 (0.1 to 2.2)
V unskilled	1.8 (−0.2 to 3.8)	2.3 (0.3 to 4.3)	2.1 (−1.3 to 5.6)	1.7 (0.4 to 3.0)
Adult social class at 26 years	p = 0.98 (p = 0.6*)	p = 0.8 (p = 0.5*)	p = 0.7 (p = 0.7*)	p = 0.6 (p = 0.5*)
I professional (reference group)	0	0	0	0
II intermediate	−0.1 (−1.5 to 1.3)	−0.0 (−1.4 to 1.3)	−1.4 (−3.7 to 1.0)	−0.2 (−1.0 to 0.7)
III skilled non-manual	−0.2 (−1.8 to 1.3)	−0.5 (−1.9 to 1.0)	−1.7 (−4.3 to 0.9)	−0.3 (−1.3 to 0.6)
III skilled manual	0.3 (−1.2 to 1.7)	0.3 (−1.1 to 1.8)	−0.9 (−3.5 to 1.7)	0.3 (−0.7 to 1.2)
IV semi-skilled	−0.1 (−1.7 to 1.6)	−0.0 (−1.7 to 1.6)	−2.0 (−4.9 to 0.9)	−0.0 (−1.1 to 1.1)
V unskilled	−0.0 (−3.0 to 2.9)	0.8 (−2.2 to 3.7)	−1.3 (−6.4 to 3.8)	−0.6 (−2.5 to 1.3)
Adult social class at 43 years	p = 0.2 (p = 0.007*)	p = 0.6 (p = 0.3*)	p = 0.5 (p = 0.3*)	p = 0.4 (p = 0.8*)
I professional (reference group)	0	0	0	0
II intermediate	0.6 (−0.7 to 1.8)	0.8 (−0.4 to 2.1)	1.7 (−0.5 to 3.9)	0.5 (−0.3 to 1.3)
III skilled non-manual	1.4 (−0.3 to 3.0)	1.2 (−0.5 to 2.8)	2.3 (−0.6 to 5.1)	0.6 (−0.5 to 1.6)
III skilled manual	1.7 (0.3 to 3.2)	1.2 (−0.3 to 2.6)	2.2 (−0.3 to 4.7)	0.3 (−0.6 to 1.3)
IV semi-skilled	1.2 (−0.6 to 3.0)	1.1 (−0.7 to 2.8)	2.1 (−1.1 to 5.2)	0.1 (−1.1 to 1.2)
V unskilled	2.3 (−0.7 to 5.2)	−0.5 (−3.4 to 2.4)	−0.4 (−5.5 to 4.8)	−1.2 (−3.1 to 0.7)

*Test for trend.

Table 2B Adjusted results from multiple regression models including social class at all time points for women: differences in means (95% confidence intervals) between each social class and the professional social class 1 (reference group)

Women	Waist-hip ratio (%) (n = 1345)	Waist-height ratio (%) (n = 1342)	Waist circumference (cm) (n = 1347)	Body mass index (kg/m ²) (n = 1337)
Father's social class	p=0.2 (p=0.02*)	p<0.001 (p<0.001*)	p=0.001 (p=0.003*)	p<0.001 (p<0.001*)
I professional (reference group)	0	0	0	0
II intermediate	-0.1 (-1.8 to 1.5)	0.3 (-1.6 to 2.3)	0.1 (-3.1 to 3.2)	0.0 (-1.3 to 1.4)
III skilled non-manual	0.2 (-1.4 to 1.8)	-0.5 (-2.4 to 1.5)	-1.1 (-4.2 to 2.0)	-0.7 (-2.1 to 0.6)
III skilled manual	0.4 (-1.2 to 1.9)	1.6 (-0.3 to 3.5)	1.5 (-1.5 to 4.5)	1.1 (-0.2 to 2.4)
IV semi-skilled	1.2 (-0.5 to 2.8)	2.9 (0.9 to 4.9)	3.7 (0.5 to 6.9)	1.5 (0.2 to 2.9)
V unskilled	1.4 (-0.6, 3.4)	2.1 (-0.4 to 4.5)	1.7 (-2.2 to 5.6)	0.6 (-1.1 to 2.3)
Adult social class at 26 years	p=0.04 (p=0.003*)	p=0.004 (p<0.001*)	p=0.05 (p=0.01*)	P=0.5 (p=0.1*)
I professional (reference group)	0	0	0	0
II intermediate	-0.2 (-1.6 to 1.2)	0.0 (-1.7 to 1.7)	0.0 (-2.7 to 2.7)	0.0 (-1.1 to 1.2)
III skilled non-manual	0.9 (-0.6 to 2.4)	1.0 (-0.8 to 2.9)	1.2 (-1.8 to 4.1)	0.4 (-0.9 to 1.6)
III skilled manual	1.0 (-0.4 to 2.5)	1.4 (-0.5 to 3.2)	1.2 (-1.6 to 4.1)	0.5 (-0.8 to 1.7)
IV semi-skilled	1.7 (0.1 to 3.3)	2.9 (1.0 to 4.9)	3.6 (0.4 to 6.7)	1.1 (-0.2 to 2.5)
V unskilled	2.2 (-0.4 to 4.7)	3.4 (0.3 to 6.5)	4.4 (-0.5 to 9.2)	0.8 (-1.3 to 2.9)
Adult social class at 43 years	p<0.001 (p=0.02*)	p<0.001 (p<0.001*)	p=0.001 (p=0.002*)	p<0.001 (p<0.001*)
I professional (reference group)	0	0	0	0
II intermediate	0.4 (-0.9 to 1.7)	0.2 (-1.4 to 1.7)	0.3 (-2.2 to 2.8)	0.1 (-1.0 to 1.2)
III skilled non-manual	0.3 (-1.3 to 1.9)	0.3 (-1.7 to 2.3)	0.5 (-2.7 to 3.6)	-0.1 (-1.5 to 1.2)
III skilled manual	0.2 (-1.3 to 1.7)	0.5 (-1.3 to 2.2)	0.5 (-2.3 to 3.4)	0.4 (-0.8 to 1.6)
IV semi-skilled	3.3 (1.6 to 5.1)	3.2 (1.0 to 5.3)	4.8 (1.4 to 8.3)	1.6 (0.1 to 3.0)
V unskilled	1.3 (-1.5 to 4.0)	5.8 (2.5 to 9.2)	8.6 (3.2 to 13.9)	4.2 (1.9 to 6.5)

*Test for trend.

in classes IV or V (table 3). Obesity levels of upwardly mobile men and women tended to be between the class they left and the class they joined. We found that men and women who experienced the greatest upward social mobility (participants from social class IV or V who moved up to classes I or II) had lower levels than study members from these classes (IV or V) who only moved up to class III non-manual or III manual (table 3). These findings were only marginally affected by adjustment for smoking and exercise (results not shown).

The analysis of downward mobility (using non-manual and manual categories) showed that those who moved down had higher means for all obesity measures than those who remained in non-manual occupations, but lower means than those who had always been in manual occupations (table 4).

DISCUSSION

Summary of results

In this study father's social class at 4 years of age influenced central and total obesity at age 53 years after adjustment for own social class in young adulthood and middle age. Independent effects of both adult social classes on obesity were also present in women, but not men. For example, this cumulative effect of lifetime socioeconomic circumstances on women's obesity represents a difference of 4.9% for waist-hip ratio or 5.6 kg/m² for body mass index between women in the most advantaged compared with those in the least advantaged circumstances. Men and women who experienced upward intergenerational social mobility had lower levels of central and total obesity compared with those who

Table 3A Upward mobility between father's and own adult social class at 43 years for men: mean obesity levels (95% confidence intervals) for the upwardly mobile and those who remained in the same social class

Men	Adult social class			
	I, II	III non-manual	III manual	IV, V
Father's social class				
Waist-hip ratio (%)	p<0.001			
Class I and II	n=234*			
	92.1 (91.3 to 92.9)			
Class III non-manual	n=170	n=36		
	92.8 (91.8 to 93.7)	93.9 (91.8 to 95.9)		
Class III manual	n=182	n=37	n=144	
	94.0 (93.1 to 94.9)	94.5 (92.5 to 96.5)	95.9 (94.8 to 96.9)	
Class IV and V	n=134	n=31	n=155	n=59
	92.7 (91.7 to 93.8)	94.5 (92.3 to 96.6)	94.2 (93.3 to 95.2)	94.6 (93.0 to 96.2)
Waist-height ratio (%)	p<0.001			
Class I and II	54.7 (53.9 to 55.4)			
Class III non-manual	55.0 (54.1 to 55.9)	55.9 (53.9 to 57.9)		
Class III manual	57.1 (56.2 to 58.0)	56.7 (54.7 to 58.6)	57.6 (56.6 to 58.6)	
Class IV and V	55.6 (54.6 to 56.6)	56.6 (54.4 to 58.7)	56.4 (55.5 to 57.4)	57.2 (55.6 to 58.7)
Waist circumference (cm)	p=0.02			
Class I and II	96.6 (95.2 to 98.0)			
Class III non-manual	96.5 (94.9 to 98.1)	98.5 (95.0 to 102.1)		
Class III manual	99.4 (97.8 to 100.9)	97.8 (94.3 to 101.3)	100.2 (98.4 to 101.9)	
Class IV and V	96.5 (94.7 to 98.3)	99.2 (95.4 to 103.0)	97.6 (95.9 to 99.3)	98.8 (96.1 to 101.5)
Body mass index (kg/m²)	p<0.001			
Class I and II	26.7 (26.2 to 27.2)			
Class III non-manual	26.8 (26.2 to 27.4)	27.0 (25.7 to 28.3)		
Class III manual	28.3 (27.7 to 28.9)	27.8 (26.6 to 29.1)	28.2 (27.5 to 28.8)	
Class IV and V	27.4 (26.7 to 28.1)	27.9 (26.5 to 29.3)	27.6 (26.9 to 28.2)	27.7 (26.6 to 28.7)

*Numbers are based on the model including waist-hip ratio and vary only slightly for the other obesity measures.

Table 3B Upward mobility between father's and own adult social class at 43 years for women: mean obesity levels (95% confidence intervals) for the upwardly mobile and those who remained in the same social class

Women	Adult social class			
	I, II	III non-manual	III manual	IV, V
Father's social class				
Waist-hip ratio (%)	p ≤ 0.001			
Class I and II	n = 220* 79.3 (78.5 to 80.2)			
Class III non-manual	n = 171 79.7 (78.7 to 80.7)	n = 31 81.2 (78.9 to 83.5)		
Class III manual	n = 196 80.1 (79.2 to 81.0)	n = 42 79.2 (77.2 to 81.1)	n = 135 81.0 (79.9 to 82.1)	
Class IV and V	n = 130 81.0 (79.9 to 82.1)	n = 46 81.6 (79.7 to 83.5)	n = 134 81.4 (80.3 to 82.5)	n = 58 84.3 (82.6 to 86.0)
Waist-height ratio (%)	p ≤ 0.001			
Class I and II	51.2 (50.1 to 52.2)			
Class III non-manual	50.3 (49.1 to 51.5)	51.9 (49.1 to 54.7)		
Class III manual	52.7 (51.6 to 53.8)	53.0 (50.6 to 55.4)	54.1 (52.8 to 55.4)	
Class IV and V	54.1 (52.7 to 55.4)	54.8 (52.6 to 57.0)	54.9 (53.5 to 56.2)	59.6 (57.6 to 61.6)
Waist circumference (cm)	p ≤ 0.001			
Class I and II	83.8 (82.1 to 85.4)			
Class III non-manual	82.0 (80.1 to 83.9)	84.2 (79.8 to 88.6)		
Class III manual	85.0 (83.2 to 86.7)	85.0 (81.2 to 88.8)	86.7 (84.5 to 88.8)	
Class IV and V	86.9 (84.7 to 89.1)	89.2 (85.6 to 92.7)	87.5 (85.4 to 89.6)	94.9 (91.7 to 98.2)
Body mass index (kg/m²)	p ≤ 0.001			
Class I and II	26.5 (25.8 to 27.2)			
Class III non-manual	25.5 (24.6 to 26.3)	26.4 (24.5 to 28.3)		
Class III manual	27.5 (26.7 to 28.2)	27.5 (25.9 to 29.1)	28.2 (27.2 to 29.1)	
Class IV and V	28.1 (27.2 to 29.0)	27.9 (26.4 to 29.4)	28.2 (27.3 to 29.1)	30.8 (29.4 to 32.2)

*Numbers are based on the model including waist-hip ratio and vary only slightly for the other obesity measures.

Table 4 Upward and downward mobility between father's and own adult social class at 43 years: mean obesity levels (95% confidence intervals) of socially mobile participants and those who remained in the same social class (using manual and non-manual categorisation of social class)

Father's social class	Men		Women	
	Adult social class		Adult social class	
	Non-manual	Manual	Non-manual	Manual
Waist-hip ratio (%)	p ≤ 0.001		p ≤ 0.001	
Non-manual	n = 458* 92.5 (91.1 to 93.0)	n = 106 93.4 (92.2 to 94.6)	n = 460 79.6 (79.0 to 80.2)	n = 135 80.5 (79.4 to 81.6)
Manual	n = 384 93.6 (93.0 to 94.3)	n = 401 94.9 (94.3 to 95.5)	n = 414 80.4 (79.8 to 81.1)	n = 376 81.9 (81.3 to 82.6)
Waist-height ratio (%)	p ≤ 0.001		p ≤ 0.001	
Non-manual	54.8 (54.3 to 55.4)	55.8 (54.6 to 56.9)	50.9 (50.2 to 51.7)	52.8 (51.4 to 54.2)
Manual	56.5 (55.9 to 57.1)	56.8 (56.3 to 57.4)	53.4 (52.6 to 54.2)	55.7 (54.9 to 56.5)
Waist circumference (cm)	p = 0.048		p ≤ 0.001	
Non-manual	96.6 (95.6 to 97.6)	97.3 (95.3 to 99.4)	83.1 (81.9 to 84.2)	85.2 (83.1 to 87.4)
Manual	98.2 (97.1 to 99.3)	98.5 (97.5 to 99.6)	86.1 (84.8 to 87.3)	89.0 (87.7 to 90.3)
Body mass index (kg/m²)	p ≤ 0.001		p ≤ 0.001	
Non-manual	26.8 (26.4 to 27.1)	27.2 (26.4 to 27.9)	26.1 (25.6 to 26.6)	27.2 (26.3 to 28.1)
Manual	27.9 (27.5 to 28.3)	27.7 (27.3 to 28.1)	27.7 (27.2 to 28.2)	28.8 (28.3 to 29.4)

*Numbers are based on the model including waist-hip ratio and vary only slightly for the other obesity measures.

remained in the same social class as their father, and this effect was not attenuated by adjustment for smoking and exercise.

Comparison with other studies

Two studies investigated the effects of early and adult socioeconomic position on central obesity.^{16, 18} Unlike our study, Brunner *et al* 1999 showed associations of own employment grade with adult central and total obesity after adjustment for father's social class in men.¹⁸ This may be because the Whitehall II study is an occupational rather than a population cohort. All participants were in the non-manual classes and childhood classes were thus unlikely to be representative. Reports of childhood social class were also retrospective and prone to recall bias. Using prospective longitudinal data and a representative spectrum

of father's occupations, we confirm the findings of studies of women that have shown effects of father's and adult social class on central and total obesity.^{16, 18} Our findings for men are consistent with those of Blane *et al* who showed an association of father's social class (measured retrospectively), but not adult social class, with adult body mass index.¹⁷

Most other studies of the influence of social class and mobility on obesity have not used measures of central obesity, or not adjusted father's for adult social class, and vice versa. Some authors considered more than two time points to assess the influence of social class experience on adult mortality and its risk factors across the life course, and allocated a score to each social class group (for example, 1 for non-manual and 2 for manual occupations) at each time point, and summed these into an overall score.^{21, 22} It has been

argued that the use of a cumulative class score is a sufficient indicator of class experience over the life course and that the direction of mobility is not important for overall mortality.²¹ Our results suggest that such an approach may not be appropriate for obesity outcomes because the effect of father's social class is generally stronger than the effect of adult social class, particularly in men. Except in the case of waist-hip ratio, only father's social class was significantly associated with obesity measures in the multiple regression models in men, indicating that early social circumstances and consequently the direction of social class change have an important influence on the development of adult obesity. Our findings also suggest that categorising social class into only manual and non-manual groups results in a loss of important information, as levels of central and total obesity were lower in participants from social class IV and V who moved to class I and II compared with those from classes IV and V who moved up to a lesser extent.

Gender differences

Our results suggest that low social class has detrimental effects on women's obesity throughout adult life, whereas in men childhood class experience seems to be particularly important. There are sex differences in the prevalence of overweight and obesity, of weight gain, and of change of body shape after puberty.²⁴ Genetic and environmental factors, childbirth, hormonal changes, and health behaviour, some of which are influenced by social position, contribute to these differences,²⁵ and may explain our differential results for social class.^{26–28} Men who remained in both generations in the skilled manual class had higher levels of central and total obesity than those remaining in the semi-skilled or unskilled occupations. In women the greatest levels of obesity were seen in those remaining in the lowest classes. It may be that the increase of earnings and purchasing power of men in this social group, have not been accompanied by an equivalent adaptation to a healthier lifestyle. Equally, participants who remained in the lowest classes during times of general advancement may represent a particularly underprivileged group. Social and economic disadvantage, especially unemployment, has been associated with high body mass index in women, but thinness (body mass index <20 kg/m²) in men.²⁹

Study limitations

The life course analysis of social class on adult obesity is complex, because social classes at different time points are related to each other. We encountered no statistical problems in fitting the multiple regression models including all three measures of social class, suggesting that multicollinearity was not a problem in our analyses.

Social class is only an approximation of many influences on health, which may be causal for the development of certain diseases. The summary into non-manual and manual classes is a simplification, which does not allow for the testing of a linear gradient across all classes. We had to use such a classification to consider the effects of downward social mobility on obesity, because downward mobility was uncommon in this generation. The use of a conventional household class measure (partner's social class) for women assumes that their social and financial position and class awareness are more closely linked to their partner's than their own occupation. Few women were employed in early adulthood in this cohort, and we could not meaningfully assign women to their own social class based on an occupation that many only held for a very limited time and often never returned to.

There are limitations in these findings, in terms of extrapolation of results to later generations. Few children in this study were obese or overweight,³⁰ compared with later

Key points

- Father's social class is inversely associated with adult central and total obesity, after adjustment for social class at 26 and 43 years.
- In women, but not men, adult social class is inversely related to obesity, after accounting for childhood circumstances.
- Upwardly mobile men and women are less obese than participants remaining in the same social class as their fathers.
- Our results on intergenerational mobility indicate the potential reversibility of early life disadvantage on obesity.

cohorts and the intragenerational and intergenerational social mobility among this generation was high.³¹

Public health implications

Upward intergenerational mobility was associated with lower obesity at age 53 years, suggesting that the long term influence of childhood social class on central and total obesity may be partly reversible. The observation of gender differences, and detection of sensitive time points for the development of social class differences in adult obesity is important to plan timely and gender specific public health interventions.

Social position influences the risk of coronary heart disease and obesity, and Great Britain is one of the industrial nations with the greatest income inequality.³² The decline in mortality rates in cardiovascular disease and the distribution of risk factors differs by occupational status.^{33–35} Any intervention that aims to target the high risk groups should consider this class gradient, particularly as obesity levels are increasing rapidly.

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