Biomedical, psychological, environmental and behavioural factors associated with adult obesity in a nationally representative sample

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Abstract

Objective: To identify personality, biomedical, and behavioural factors associated with adult obesity in a large longitudinal sample.

Method: In total, 5360 participants with data on personality, neurological functioning, maternal smoking during pregnancy, education and occupation, physical exercise, adult self-reported BMI and obesity were included in the study. Obesity at 55 years was the outcome variable.

Results: The rates of obesity increased from 9.5% to 22.8% from age 33 years to age 55 years. Logistic regression analyses (adjusted estimates) showed that childhood neurological functioning (OR=1.32: 1.07-1.63, $p<.01$), maternal smoking during pregnancy (OR=1.42: 1.22-1.65, $p<.001$), educational qualifications (OR=0.54: 0.37-0.79, $p<.01$), trait conscientiousness (OR=0.80: 0.74-0.86, $p<.001$), and physical exercise (OR=0.87: 0.82-0.92, $p<.001$) were significant predictors of obesity at age 55 years for both men and women. Trait extraversion for men (OR=1.16: 1.07-1.26, $p<.001$) and trait emotional stability for women (OR=0.90: 0.82-0.99, $p<.05$) were also significant predictors of the outcome variable.

Conclusion: Biomedical, psychological, environmental and behavioural factors were all associated with adult obesity.

Keywords: Personality traits, Childhood Neurological Conditions; Maternal Smoking; Physical Exercise, Obesity; Longitudinal

Introduction

Being overweight and obese is a major risk factor for a number of chronic diseases, including diabetes, cardiovascular diseases, musculoskeletal disorders, and cancers (WHO, 2003) [1]. Evidence shows that the obesity epidemic is increasing: according to estimates from Public Health England, two thirds of adults and a quarter of children between two and ten years old are overweight or obese with increased health and social care costs [2], and hence the increase in studies on aetiology of obesity.

Studies have shown many factors associated with adult obesity and some of which will be explored in this study.

Social Class and Obesity

Previous studies have shown the link between *socioeconomic conditions* and obesity [3-4], indicating that childhood socioeconomic conditions may influence adult obesity. Specifically, those who are at the lower levels of social status tend to experience more poor health in general.

Maternal Smoking and Obesity

Studies have suggested that environmental chemicals may play a role in the development of childhood obesity and metabolic disorders, especially when exposure occurs early in life [5]. Supporting evidence has been found in both affluent and less affluent nations [6-7]. There is also some evidence showing that the adverse effects of maternal smoking during pregnancy extend to adolescence [8] and beyond [9].

Neurological Functioning and Obesity

One study showed that a set of childhood poor neurological functioning measures were significantly associated with obesity in adulthood at age 33 after controlling for childhood

behaviour adjustment and BMI, and a number of demographic and epidemiological factors [10]. The current study uses the same data set with the latest follow-up data examining whether childhood neurological function has long lasting effect on obesity 48 year later at age 55 years.

Physical Exercise and Obesity

There is evidence showing that exercise is significantly associated with adult obesity when these two variables are measured at the same time [11]. The current study examines whether the frequency of exercise is an independent predictor of adult obesity after controlling for a set of socio-demographic, environmental, and psychological factors.

Personality Factors and Obesity

Whilst various studies have shown that obesity is determined by genetic, socioeconomic and environmental factors, a number of studies have also examined the association between psychological factors such as personality (12-13] and intelligence [14]. Trait conscientiousness, with features like self-discipline, prudence, and self-control, has been found to be a protective factor for many health outcomes [15-16]. In a meta-analysis of 20 psychological studies on the associations between conscientiousness and health, Bogg and Roberts [17] showed that higher levels of conscientiousness were significantly and positively linked to longevity. Chapman and colleagues [12] examined a set of socioeconomic indices and personality traits in relation to adult obesity and found that, for both men and women, trait conscientiousness was significantly and negatively associated with adult obesity.

This study also looks at trait neuroticism which is associated with anxiety and depression. Obesity increases the risk of mental illness such as depression and anxiety [18-20]. In a meta-analysis of 15 longitudinal studies (N = 58,745), Luppino and colleagues [18] confirmed a reciprocal link between depression and obesity.

Childhood Intelligence and Obesity

There is also evidence showing the association between childhood intelligence and adult obesity [14]. Less intelligent children and adults may have less well-paid jobs and less money to spend on quality food. They may also pay less attention to health education messages in part aimed at weight control. Indeed Kanazawa [21-22] has shown that childhood intelligence, if measured accurately, does significantly influence adult obesity net of education and other possible confounds.

Specifically, the aims of the study are four-fold. *First,* to investigate whether psychological factors (personality traits and childhood intelligence) are associated with obesity at age 55 years; *second,* whether there are long lasting effects of early neurological function on the outcome variable 48 years later; *third*, whether there is an early environmental factor (maternal smoking during pregnancy) that is independently associated with obesity in adulthood; and *fourth*, whether a behavioural factor (exercise at age 50 years) is independently associated with obesity at age 55 years.

We formulated five specific hypotheses: H1) Personality traits conscientiousness and emotional stability measured at age 50 years are associated with obesity at age 55 years; H2) Childhood neurological functioning is associated with obesity 48 years later; H3) Childhood intelligence is associated with obesity at age 55 years; H4) Maternal smoking during pregnancy is associated with obesity at age 55 years; H5) Physical exercise measured at age 50 years is associated with obesity at age 55 years,

Method

Sample

The National Child Development Study 1958 (NCDS) is a large-scale multidisciplinary longitudinal study of the 17,415 individuals who were born in Great Britain in a week in March 1958 [23-24]. The participants were recruited as part of a perinatal mortality survey, and they have been followed up nine times with the latest follow-up in 2013 when cohort members were at age 55 years. At age 55 years, 8,483 (response = 73.4%) participants provided information on their BMI. The analysis presented here is based on 5,630 participants with complete data on all the measures we were interested in. Attrition of the sample has resulted in an under-representation of those participants who are most disadvantaged, but the remaining sample is generally representative of the original sample [25].

Measures

1. *Childhood measures: Parental social class* at birth was measured by the Registrar General's Classification of Social Class (RGSC). RGSC is defined according to occupational status and the associated education, prestige or lifestyle [26], and is assessed by the current or last held job. Where the father was absent, the social class (RGSC) of the mother was used. RGSC was coded on a six-point scale (I= unskilled occupations to 6 = professional) [27]. *Mother's education* was measured by the age left full-time education. Parental BMI was based on self-report of height and weight of cohort members' parents, and was computed following the formula kg/m^2 (weight in kilograms/ height in $meters^2$). The *neurological function variables* (poor hand control, poor co-ordination, overall clumsiness) were reported by teachers when cohort members were at age 7 years. Teachers were instructed to score 0= "Doesn't apply" (if the description does not fit the child), 1= "Applies somewhat" (if it is a marginal case), 2= "Certainly applies" (if the child certainly fits the description). As the assessments of neurological function were based on teachers' observation of pupils, the total score of the

Bristol Social Adjustment Guide with 150 items [28], was used as a control variable to reduce the possibility that deviant behaviour influenced the teachers' perceptions of children. Other childhood control variables include the height of the cohort members which was measured by trained medical staff when subjects were at age 7 years, gestational age and birth weight, mother's age at cohort member's birth. *Childhood cognitive ability tests* were measured when subjects were at age 11 consisting of 40 verbal and 40 non-verbal items administered at school [29]. *Maternal smoking* during pregnancy was measured at birth. Mothers were interviewed and provided information on whether they were tobacco users during pregnancy with Yes/No responses.

2. *Adulthood measures: BMI* was based on cohort members self-report on their height and weight and was computed following the formula kg/m^2. Obesity at age 33 and 55 years defined as body mass index ≥ 30 according to World Health Organisation recommendation [30]. At age 33, participants were asked about their highest academic or vocational qualifications. Responses are coded to the six-point scale of National Vocational Qualifications levels (NVQ) which ranges from 'none' to 'university degree'/equivalent NVQ 5 or 6. Data on current or last occupation held by cohort members at age 55 were coded according to the RGSC, described above, using a 6-point classification. *Personality traits* were assessed at age 50 years by the 50 questions from the International Personality Item Pool (IPIP) [31]. Responses (5-point, from "Strongly Agree" to "Strongly Disagree") are summed to provide scores on the so-called 'Big-Five' personality traits: Extraversion, Emotional Stability/Neuroticism, Conscientiousness, Agreeableness, and Intellect/Openness. A preliminary analysis showed that there were no significant associations between traits Agreeableness and Openness and the outcome variable thus these two factors were excluded from the analyses. Alpha was 0.73 for Extraversion, .82 for Emotional Stability and 0.77 for Conscientiousness in the study. The z scores were used for regression analysis. At age 50 cohort members provided information on the frequency of their

physical exercise. Responses were coded to the six-point scale (1= less often, 2= 2-3 times a month, 3= once a week, 4=2 or 3 days a week, 5=4 or 5 days a week, 6=every day).

Statistical Analyses

To investigate whether biomedical, psychological, environmental and behavioural factors were independently associated with adult obesity, first, we examined the characteristics of the study population according to prevalence of obesity at age 33 and 55 years; Second, we provided the correlation matrix of all the variables used in the study in Appendix 1; following this, a series of logistic regression analyses (in the total sample and by sex) were conducted using STATA version 14 with obesity measured at age 55 years as the dependent variable. Two models were designed: regression coefficients in Model 1 were unadjusted; and regression coefficients in Model 2 were adjusted for gestational age and birth weight, mother's age at cohort member's birth, paternal and maternal BMI, childhood height and behavioural adjustment. Our choice of these variables was based on the previous literature in this area.

Results

Descriptive Analysis

Table 1 shows the characteristics of the study population according to prevalence of obesity at age 33 and 55 years. There was an increase of the prevalence of obesity from age 33 years to age 55 years (9.5% to 22.8%). Table 1 also shows that cohort members with low parental social class and current occupation (partly skilled) and no qualification had higher rates of obesity. Interestingly those with the lowest occupation (unskilled) did not have high rates of obesity for which there is no obvious explanation.

Insert Table 1 about here

Correlational Analysis

Pearson correlation coefficients of the variables examined in the study are presented in Appendix 1. Obesity at age 55 was significantly ($p<.05$ to $p<.001$) and negatively associated with parental social class and mother's education, childhood intelligence, educational qualifications and current occupation; and was positively associated with maternal smoking during pregnancy and childhood neurological function measures. Obesity was also significantly and negatively associated with personality traits conscientiousness and emotional stability as well as physical exercise.

Regression Analysis

To investigate whether childhood neurological function measures, maternal smoking during pregnancy, childhood intelligence, personality traits and physical exercise were independently associated with adult obesity, logistic regression analyses were conducted for the total sample, and for the male and female sub samples. Table 2 shows the results (both adjusted and unadjusted estimates were presented).

Insert Table 2 about here

For the total sample, maternal smoking during pregnancy, childhood neurological function (overall clumsiness), the highest educational qualification (university degree compared to no education), traits extraversion and conscientiousness, and exercise were all statistically significantly and independently associated with the outcome variable. Childhood intelligence was not significantly and independently associated with the outcome variable ($p=.08$) though it was in the expected direction.

Table 2 also shows that for both men and women, five factors (maternal smoking, childhood clumsiness, the highest educational qualification (men only), trait conscientiousness and exercise) were independent predictors of obesity in adulthood. Whereas the highest parental social class (professional family background) and trait extraversion for men, and mother's education and trait emotional stability (neuroticism) for women, were also independently associated with the outcome variable.

As can be seen in Table 2, the unadjusted estimates and the adjusted estimates were similar for the total sample and for the subsamples by sex. For the total sample, it seemed that after adjusting for a set of possible confounding factors, the positive association between childhood clumsiness and adult obesity was slightly reduced (OR changed from 1.46 (1.22, 1.75) to 1.32 (1.07, 1.63), statistical significance level changed from $p<.001$ to $p<.01$); whereas the positive association between maternal smoking and the outcome variable became slightly stronger (OR changed from 1.22 (1.07, 1.40) to 1.42 (1.22, 1.65), statistical significance level changed from $p<.01$ to $p<.001$).

Discussion

Main Findings of this study

First, the current study shows that one of the three measures of poor neurological functioning (clumsiness) in childhood has a long lasting adverse effect: a marker of obesity in adulthood 48 years later. This confirms H2 but is related to only one of the three neurological measures. The association is independent of a set of socio-demographic, psychological, environmental and behavioural factors. This suggests that interventions and rehabilitations should be considered in early years when children were first observed by teachers or parents, so that the potential adverse effect of such condition on later BMI and obesity might be minimised. However, there may be other causes of clumsiness, rather than some neurological defect.

Second, the current study has extended previous findings by providing evidence that maternal smoking during pregnancy is associated with a greater risk of obesity over 50 years. This confirms H4. As predicted, maternal smoking was negatively associated with occupation (r=-.08, p<.001) and education (r=-.14, p<.001). There might be a possible confounding by social factors: the independent association between maternal smoking and obesity in adulthood after adjustment for personality and socioeconomic factors across the life-course supports a more direct influence, suggesting smoking during pregnancy should always be strongly discouraged. For some exposures there may be over-adjustment: if maternal smoking causes a form of foetal malnutrition that influences insulin signalling, then one might expect a reduction in birth weight (which was adjust for in the study).

Public health professionals, educators, and policy makers may help families, especially young mothers from lower social class with less education, to change this detrimental behaviour. In-utero exposures due to smoking during pregnancy may increase the risk of obesity through prenatal programming, resulting in lifelong metabolic dysregulation, possibly due to foetal malnutrition or toxicity [11]. However, these mothers were giving birth over 55 years ago when the harmfulness of smoking were less well known and the incidence has dropped considerably from 48% in 1974 to 19% in 2014 (ONS, 2016).

Third, personality traits are independently associated with obesity in adulthood after taking account a set of sociodemographic, biomedical, environmental and behavioural factors. This confirms H1. Many studies examining personality correlates of a wide range of health issues have consistently implicated Conscientiousness and Emotional Stability [15]. Both traits are associated with a healthier emotional, physical and social life-style as well as better social relationships and occupational success [32]. Importantly it has been demonstrated that people can learn to become more conscientious, which has an effect on their total life-style [33]. Public

health interventions should emphasise the many benefits of being conscientious (planful, organised and reliable) for all aspects of personal welfare.

In addition to conscientiousness, which was significant for both sexes, two other traits were significant: emotional stability for women and extraversion for men. Most personality studies show women score higher than men on neuroticism, which is associated with anxiety, depression, hypochondriasis and low self-esteem [32]. As noted above depression has been found to be associated with obesity both as a cause and consequence. There are a number of reports which suggest that women tend to over-eat, possibly as a comfort [34], when they encounter stress and emotional problems with partners, and overweight in turn may worsen depression and lower self-esteem.

For males it was Extraversion that was associated with obesity found in the study. Extraverts are sociable, impulsive and carefree [32]. It could be that the socialising of adult males (e.g. in bars and clubs) is a major contributor to their obesity along with lower impulse control and wishful thinking that their eating and drinking will have little long-term effect [15]

Fourth, in this study, education was significantly associated with obesity in adulthood, not intelligence as hypothesised in H3. Compared to those who had little or no education, those who obtained university degree(s) were less likely to be obese at age 55 years. One of the explanations might be that educational attainment is strongly associated with intelligence [35-36]. In one study [37], it shows that childhood intelligence was inversely associated with all major causes of mortality. This could be related to lifestyle, quality of life, and genetic factors. On the other hand, social inequality in health may also play a role [38-39]. People with high educational qualifications in better occupations tend to have a better sense of self-control (internal locus of control) over life and work which contributes to general health [32]. They may also be more knowledgeable in using health service. Children from socioeconomically disadvantaged families might be more likely to consume poor quality food (high fat food such

as junk food containing high levels of calories from sugar and fat with little fibre, protein, or vitamins) which may affect health and weight control in adulthood. Feasible ways need to be found to direct health messages to this particular group of disadvantaged people.

Fifth, this study shows as expected that exercise is an independent predictor of obesity. This confirms H5. All health professional recommend appropriate but constant exercise for its many benefits including weight control [2]. However, it is not clear what motivates people to take a regular exercise, though this has been linked to personality factors [32].

What is already known on this topic

We know about many behavioural, medical, psychological and sociological correlates and predictors of adult obesity. Both cross-sectional and longitudinal studies have confirmed the observations and hypotheses of experts in many areas. We know that social class is related to obesity which itself is related to intelligence and education. We know there are long term consequences of maternal smoking. Further, we are beginning to understand which, why and how personality factors influence obesity.

What this study adds

Because this is a longitudinal study with a large representative sample, it adds a better understanding of the causes, not just correlates, of adult obesity. More importantly because we examined seven different classes of predictor variables: parental social class and current occupation, maternal smoking, childhood neurological conditions, childhood intelligence, educational qualifications, personality traits and physical exercise we could examine the relative contribution of all these variables simultaneously on adult obesity. The power of maternal smoking as a significant predictor of adult obesity 55 years later was a striking finding and one which can inform health policy and education.

Limitations of this study

As all cohort studies, the measures and variables used in this study are not by study design, but by data availability, thus limits the scope of the study. Although our study is based on a birth cohort with representative sample, the attrition of respondents over time was greater among the socioeconomically disadvantaged groups. Our results may thus be a conservative estimate of the long-term influence of social inequalities experienced during childhood. The outcome variable obesity at age 55 years was based on self-reported height and weight of cohort members, rather than being measured by medical professionals. However, we may assume that these measures have reasonable precisions, as these measurements are not particularly difficult to make, and the self-reported health outcomes have been found to have high degree of validity [40-42]. Furthermore, it would be very desirable to have had personality traits measured earlier, so that the stability and change of these traits in relation to the outcome variable could be investigated.

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Table 1. Characteristics of the study population according to prevalence of obesity at 33 and 55 years.

Measures	n	%	Obesity at age 33 %	Obesity at age 55 %
Sex				
Male	2788	52.0	9.4	23.4
Female	2572	48.0	9.6	22.1
Parental social class at birth				
Unskilled (V)	380	7.1	10.5	26.1
Partly skilled (IV)	626	11.7	12.9	26.0
Skilled manual (III)	2611	48.7	10.6	24.9
Skilled non-manual (III)	598	11.2	6.5	20.1
Managerial\tech (II)	480	15.7	5.8	17.3
Professional (I)	305	5.7	4.5	14.8
Educational qualifications at age 33				
No qualifications	372	6.9	17.2	34.1
CSE 2-5/equivalent NVQ1	585	10.9	12.8	25.6
O Level/equivalent NVQ2	1893	35.3	10.3	24.2
A level/equivalent NVQ 3	825	15.4	7.8	21.7
Higher qualification/equivalent NVQ4	850	15.9	8.2	21.8
University degree/equivalent NVQ 5, 6	835	15.6	4.9	14.5
Current occupation				
Unskilled (V)	116	2.2	7.8	17.2
Partly skilled (IV)	612	11.4	15.4	25.7
Skilled manual (III)	965	18.0	11.5	26.0
Skilled non-manual (III)	1049	19.6	8.8	21.8
Managerial\tech (II)	2248	41.9	8.2	22.0
Professional (I)	370	6.9	4.9	18.6

Table 2. Odds ratios (95% CI) for obesity at age 55, according to parental social class, mother's education, maternal smoking during pregnancy, childhood neurological conditions, childhood intelligence, education and occupation, personality traits and exercise.

Measures	All			Males			Females		
	Unadjusted Odds Ratio (95% CI)	**Adjusted Odds Ratio (95% CI)†**	***p*-value[#]**	**Unadjusted Odds Ratio (95% CI)**	**Adjusted Odds Ratio (95% CI)†**	***p*-value[#]**	**Unadjusted Odds Ratio (95% CI)**	**Adjusted Odds Ratio (95% CI)†**	***p*-value[#]**
Parental social class at birth (*unskilled as reference group*)									
Partly skilled	0.96 (0.72, 1.27)	1.00 (0.80, 1.08)	0.978	0.83 (0.59, 1.17)	0.84 (0.59, 1.20)	0.334	1.08 (0.72, 1.61)	1.09 (0.73, 1.64)	0.666
Skilled manual	0.96 (0.75, 1.21)	1.07 (0.81, 1.41)	0.630	0.81 (0.61, 1.08)	0.85 (0.64, 1.14)	0.291	1.15 (0.82, 1.60)	1.20 (0.85, 1.69)	0.309
Skilled non-manual	0.75 (0.56, 1.02)	0.83 (0.59, 1.17)	0.294	0.85 (0.56, 1.26)	0.87 (0.57, 1.33)	0.529	0.91 (0.59, 1.40)	1.03 (0.67, 1.60)	0.883
Managerial\tech	0.67 (0.50, 0.90)	0.80 (0.57, 1.11)	0.187	0.69 (0.47, 0.97)*	0.76 (0.53, 1.09)	0.131	0.70 (0.46, 1.07)	0.80 (0.52, 1.24)	0.321
Professional	0.64 (0.43, 0.96)	0.78 (0.49, 1.23)	0.280	0.42 (0.24, 0.71)**	0.47 (0.27, 0.80)**	0.006	0.95 (0.56, 1.65)	1.10 (0.61, 1.96)	0.757
Mother's education	0.95 (0.90, 1.00)	0.94 (0.59, 1.17)	0.053	0.97 (0.91, 1.03)	0.97 (0.90, 1.03)	0.307	0.91 (0.85, 0.97)*	0.92 (0.85, 0.98)*	0.025
Maternal smoking during pregnancy	1.22 (1.07, 1.40)**	1.42 (1.22, 1.65)***	<0.001	1.18 (1.00, 1.40)*	1.30 (1.22, 1.65)**	0.003	1.21 (1.00, 1.46)**	1.32 (1.09, 1.61)**	0.005
Poor hand control at age 7	1.03 (0.89, 1.19)	0.97 (0.83, 1.14)	0.738	1.03 (0.88, 1.20)	1.03 (0.88, 1.21)	0.700	1.22 (0.97, 1.54)	1.25 (0.99, 1.57)	0.059
Poor co-ordination at age 7	0.94 (0.78 1.13)	0.97 (0.78 1.20)	0.769	0.86 (0.70 1.06)	0.88 (0.71 1.08)	0.223	1.03 (0.77, 1.38)	1.13 (0.83 1.53)	0.446
Overall clumsiness at age 7	1.46 (1.22, 1.75)***	1.32 (1.07, 1.63)**	0.009	1.39 (1.15, 1.69)**	1.24 (1.02, 1.52)*	0.034	1.70 (1.26, 2.28)**	1.39 (1.02, 1.90)*	0.035
Childhood intelligence at age 11	0.97 (0.90, 1.04)	0.93 (0.86, 1.01)	0.077	0.98 (0.90, 1.07)	0.99 (0.90, 1.08)	0.790	0.95 (0.86, 1.06)	0.91 (0.82, 1.01)	0.071
Educational qualifications (*no qualification as reference group*)									
CSE 2-5/equivalent NVQ1	0.72 (0.54, 0.96)*	0.76 (0.54, 1.06)	0.102	0.84 (0.58, 1.23)	0.87 (0.59, 1.29)	0.494	0.59 (0.40, 0.86)**	0.76 (0.51, 1.12)	0.162
O Level/equivalent NVQ2	0.68 (0.53, 0.88)*	0.77 (0.57, 1.04)	0.089	0.76 (0.55, 1.06)	0.81 (0.58, 1.13)	0.214	0.59 (0.42, 0.83)**	0.79 (0.55, 1.23)	0.196
A level/equivalent NVQ 3	0.68 (0.51, 0.91)*	0.77 (0.55, 1.08)	0.134	0.74 (0.52, 1.06)	0.79 (0.55, 1.14)	0.211	0.56 (0.36, 0.87)**	0.68 (0.43, 1.08)	0.103
Higher qualification/ equivalent NVQ4	0.71 (0.53, 0.95)*	0.85 (0.61, 1.18)	0.329	0.70 (0.47, 1.01)	0.76 (0.52, 1.12)	0.164	0.68 (0.45, 1.00)	0.98 (0.65, 1.49)	0.936
University degree/ equivalent NVQ 5, 6	0.46 (0.33, 0.63)***	0.54 (0.37, 0.79)**	0.001	0.49 (0.32, 0.73)**	0.53 (0.35, 0.81)**	0.003	0.40 (0.25, 0.63)***	0.65 (0.40, 1.04)	0.073
Current occupation (*unskilled as reference group*)									

Partly skilled	1.46 (0.86, 2.47)	1.25 (0.69, 2.23)	0.461	1.43 (0.70, 2.89)	1.51 (0.73, 3.13)	0.264	1.99 (0.97, 4.12)	1.62 (0.82, 3.18)	0.164
Skilled manual	1.42 (0.83, 2.37)	1.23 (0.70, 2.17)	0.469	1.38 (0.71, 2.68)	1.46 (0.73, 2.89)	0.282	1.44 (0.65, 3.21)	1.20 (0.55, 2.59)	0.649
Skilled non-manual	1.35 (0.70, 2.26)	1.36 (0.77, 2.40)	0.283	1.35 (0.66, 2.75)	1.80 (0.90, 3.61)	0.096	1.87 (0.92, 3.81)	1.97 (1.03, 3.80)	0.142
Managerial\tech	1.50 (0.90, 2.50)	1.46 (0.84, 2.54)	0.178	1.45 (0.74, 2.84)	1.58 (0.79, 3.14)	0.195	2.10 (1.03, 4.24)	1.89 (0.99, 3.63)	0.155
Professional	1.41 (0.79, 2.53)	1.30 (0.69, 2.47)	0.414	1.45 (0.69, 3.04)	1.62 (0.79, 3.46)	0.208	1.92 (0.81, 4.54)	1.60 (0.70, 3.68)	0.267
Extraversion	1.13 (1.06, 1.20)***	1.12 (1.04, 1.20)**	0.002	1.17 (1.07, 1.27)***	1.16 (1.07, 1.26)***	<0.001	1.07 (0.98, 1.17)	1.07 (0.97, 1.17)	0.163
Conscientiousness	0.80 (0.75, 0.85)***	0.80 (0.74, 0.86)***	<0.001	0.88 (0.81, 0.95)**	0.88 (0.81, 0.96)**	0.002	0.77 (0.71, 0.83)***	0.77 (0.71, 0.85)***	<0.001
Emotional stability	0.95 (0.89, 1.01)	0.94 (0.87, 1.01)	0.076	0.96 (0.89, 1.05)	0.96 (0.88, 1.04)	0.339	0.91 (0.83, 1.01)*	0.90 (0.82, 0.99)*	0.029
Exercise	0.87 (0.83, 0.92)***	0.87 (0.82, 0.92)***	<0.001	0.90 (0.83, 0.96)**	0.91 (0.85, 0.97)**	0.004	0.87 (0.81, 0.93)***	0.86 (0.80, 0.93)***	<0.001

Note. *p<.05; **p<.01;***p<.001. [#] p-value for the adjusted models. †controlling for gestational age and birth weight, mother's age at cohort member's birth, paternal and maternal BMI, childhood height and behavioural adjustment.

Appendix 1. Pearson product-moment correlations of obesity and other variables in the study.

	Measures	Mean (SD)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Sex	.48 (.50)	_														
2.	Obesity age 55	.24 (.42)	-.01	_													
3.	Parental social class	3.30 (1.24)	-.02	**-.10**	_												
4.	Mother's education	15.52 (1.68)	.01	**-.08**	.37	_											
5.	Maternal smoking during pregnancy	.31 (.46)	.01	**.06**	-.11	-.12	_										
6.	Poor hand control age 7	.20 (.48)	-.14	**.07**	-.08	-.02	.07	_									
7.	Poor co-ordination age 7	.13 (.38)	-.08	**.05**	-.03	-.01	.01	.40	_								
8.	Overall clumsiness age 7	.13 (.38)	-.13	**.09**	-.05	-.03	.02	.37	.49	_							
9.	Childhood intelligence	103.3 (14.06)	.07	**-.09**	.28	.23	-.13	-.24	-.15	-.18	_						
10.	Educational qualifications age 33	2.64 (1.48)	-.11	**-.11**	.34	.31	-.14	-.15	-.07	-.10	.50	_					
11.	Current occupation age 55	4.08 (1.24)	-.01	**-.03**	.23	.17	-.08	-.12	-.08	-.10	.35	.46	_				
12.	Extraversion age 50	29.42 (6.68)	.06	**.02**	.04	.06	.03	-.03	-.05	-.04	.05	.07	.13	_			
13.	Conscientiousness age 50	33.89 (5.36)	.08	**-.10**	.03	.02	-.02	-.10	-.09	-.09	.05	.07	.08	.16	_		
14.	Emotional stability age 50	28.61 (7.19)	-.14	**-.05**	.03	.01	.02	-.02	-.04	-.03	.09	.10	.07	.23	.19	_	
15.	Physical exercise age 50	4.28 (1.36)	.07	**-.06**	-.02	.01	.03	.02	-.01	.03	-.06	-.07	-.05	.03	.02	-.01	_

Note. Variables were scored such that a higher score indicated being female, a higher score on obesity, a more professional occupation for parents, later years mother left full-time education, smoking during pregnancy, childhood neurological conditions, higher scores on childhood intelligence, highest educational qualification, more professional occupation, a higher score on extraversion, conscientiousness, and emotional stability, and a higher score on frequency of physical exercise. Associations between obesity at age 55 and other variables are in bold.