Does Fat Damage Brain?
The Effect of Obesity on Cognitive and Basic Skills

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PRELIMINARY VERSION

Abstract

We use data from an English cohort to assess whether obesity and overweightness influence individuals' cognitive ability when 10 years old and their literacy and numeracy skills at 34 years. In order to understand whether this relationship is causal, we employ instrumental variables, using both parents' BMI as instruments for cohort members' Body Mass.

We perform our analysis using also dummies describing individual weight status instead of the continuous BMI variable and we exploit information about individuals' BMI at different ages to study this issue from a dynamic point of view.

Our results show that weight excess has a significant negative causal effect on both cognitive ability and basic skills.

Keywords: Health, Obesity, Body Mass Index, Cognitive Ability
JEL Classification: I12, I14, J62

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1. Introduction

Recent medical researches[1] have proved the existence of a negative relationship between obesity and cognitive skills, finding that the Intelligent Quotient (IQ) and fatness are negatively correlated.

Also in the field of economics literature some studies analyzed the consequences of obesity on cognitive ability, measured by standardized tests, and educational outcomes, such as school performance.

We investigate these issues using data from the British Cohort Study, that follows a cohort of U.K. individuals from their birth, in 1970, until nowadays. This longitudinal dataset contains the results of a cognive test, the British Ability Scale (BAS), sit in 1980, when cohort members are 10 years old, and of a basic literacy and numeracy test, taken in 2004 at the age of 34. In the same years information about individuals' BMI are recorded. Therefore, we can study the impact of current BMI levels on individuals' test scores. Moreover, we can evaluate the lagged effect of 1980 Body Mass levels on the basic skill test performed in 2004 and study whether a change in the weight status from childhood to adulthood may affect the test result.

The topic is of great interest since cognitive ability, educational achievements and basic skills are important determinants of individual's productivity and economic outcomes.

Several studies have indeed highlighted the negative effect of weight excess on wages. However, not enough attention has been put on the potential channels driving this relationship: a decline in cognitive ability caused by obesity might explain part of the wage gap found in the literature between obese and non-obese workers.

For this reason, policies targeted to reduce obesity rates may have economic implications that go beyond the well known savings in health expenditure.

Several mechanisms can explain the negative relationship found between weight excess and individuals' skills:

a) Obesity could cause a decline in cognitive ability. One possible medical explanation is that the hormones secreted by fat could damage brain's cells (Cournot M. et al., 2006). Cognitive problems can also follow from deficiencies of certain micronutrients such as zinc, iron and iodine (Taras, 2005) for which overweight people are at risk because of the consumption of cheap, energy-rich but nutrient-poor food (Nead et al. 2004).

[1] Archana Singh-Manoux et al. (2012), Cournot M. et al. (2006), Thompson P.M. et al. (2010).

Moreover, it is well known that weight problems are responsible for many chronic diseases (such as cardiovascular disease, hypertension, coronary-heart diseases, sleep disorders, etc.) that could alter cognitive functioning.

b) There can be adverse psycological effects of obesity. Strauss (2000) found a positive correlation between weight problems and low self-esteem, while Faith, Matz and Jorge (2002) documented a positive association linking depression with obesity. Phycological problems, as well as health disorders, could be responsible for a decline in cognitive functioning.

c) Weight excess could harm human capital accumulation. For example obese children are more likely to be absent from school than non-obese (Geiner et al. 2007), they can be discriminated by teachers (Redline et al. 1999) and bullied by their peers. This can negatively influence their learning environment, resulting in a lower educational achievement, which is important in determining cognitive ability.

d) The association might be driven by unobservable confounders like individual and family background characteristics that simultaneuosly affect both weight and cognitive skills. In particular, parental cognitive skills, socio-economic postion and attitudes toward education might be important omitted variables.

Part of the negative relationship linking obesity and cognitive ability can of course be explained by reverse causality: differences in cognitive ability might cause differences in adiposity. Individuals with lower IQ and education might be less able to acquire and process health information and can therefore choose unhealthy behaviours and lifestyle that may lead to obesity. In addition, it is possible that they are more likely to suffer from phycological discomfort: discrimination, lower popularity and engagement in social activities could induce depression and over-eating.

We address the reverse causality and the unobserved heterogeneity issues by means of instrumental variables. Following the approach by Cawley (2000, 2004), Brunello and d'Hombres (2005) and Sabia (2007) we instrument individual's BMI with a relative's BMI. In particular, from our dataset we can exploit information about both mother's and father's body mass. As made clear by previous studies, parents' BMI is likely to satisfy the two key requirements for being an IV: it is strongly correlated with that of their offsprings[2] (conditional on other covariates) and is likely to be exogenous, that is uncorrelated with the error term in the explanatory equation.

[2] See Comuzzie and Allison (1998) and Castelnovo (2013)

The availability of two instruments provide us with an additional element to check their validity, that is the possibility to perform an overidentification test.

The outline of this paper is as follows. Section 2 contains a literature review, the data used are described in section 3, while section 4 presents the empirical models and the estimation strategies employed. In section 5 we show our results. Conclusions follow.

2. Literature Review

It is well known from the medical literature that obesity has important negative consequences on individuals health. This has in turn relevant economic implications that have drawn the attention of the economists who initially focused on the effect of obesity on outcomes such as wages and employment probability. Within this literature we can distinguish between studies investigating the existence of an association between weight excess and economic outcomes and those trying to understand whether such relationship is actually causal.

One of the firsts paper looking at the consequences of obesity on wages is Sargent and Blanchflower (1994). They found a negative association between obesity at 16 years and earnings at age 23 for British women but not for men. Female adolescents who were in the top 10% of the body mass index distribution at age 16 earned 7.4% less than their non-obese peers and those in the top 1% earned 11.4% less, while no statistically significant effect is found for males.

Similar results are obtained for U.S. individuals by Han, Norton and Powell (2009). They found a negative correlation between late teen BMI and future wages and they also introduce a distinction between the direct and the indirect effects of obesity. The direct BMI wage penalty operates through discrimination by employers who want to avoid obese employees who may have lower productivity or higher health care costs. The indirect relationship between BMI and wages can be driven by two channels. First, late teen BMI can affect education, which in turn, influences wages. Secondly, education may also affect occupation choice that, again, has an impact on wages.

A significant portion of the effect of BMI on labor market outcomes may occur prior to employment and therefore previous studies that estimate the BMI wage penalty conditional on education and occupation underestimate such penalty.

Their results for women show a total 0.96% decrease in wages for each additional unit of late teen BMI with the indirect effects stemming from education and occupation choices making up 19% of the total wage penalty. As in Sargent and Blanchflower (1994), they did not find a significant direct effect of BMI on wages for men. However, they showed that higher levels of late teen BMI for men slightly decreases hourly wages via the indirect pathways of education and occupation choice.

Averett and Korenman (1996) showed that in U.S.A. obese women have lower family incomes while results for men are weaker and mixed. There is also some evidence of labor market discrimination against obese women. However, differences in marriage probabilities and in spouse's earnings account for 50 to 95% of their lower economic status.

Focusing not only on wages as an economic outcome, Cawley and Danziger (2005) found that high body weight is a great barrier to labor market success for white women but not for African-American women. Among white women, they found a significant negative correlation between weight and labor market outcomes such as employment, hours worked, and earnings.

All of the studies cited above established the existence of a negative association but not of a causal effect of obesity on wages, since they do not account for the potential endogeneity of individuals' BMI.

Probably the first study facing this endogeneity problem is Cawley (2000), who exploited information on a sibling's BMI as an IV for individual's own BMI. The outcome of interest is now employment disability and the results reveal no causal effect of body weight.

The same IV approach is used in Cawley (2004), but here the relation studied is the one netween BMI and wages. Using data from the National Longitudinal Survey of Youth (NLSY) Cawley found that weight has a negative causal impact only on white females wages. No evidence is found for males nor for black females.

On the contrary, using data from 9 E.U. countries and the avregare of relatives' BMI as an instrument, Brunello and d'Hombres (2005) found that the causal impact of obesity on wages is indipendent of the gender. It is negative an statistically significant for countries belonging to the "olive belt" an positive for Nothern and Central Europe States.

A different instrument, that is genetic markers (whose validity will be discussed later in the paper), is employed in Norton and Han (2008), that found no causal effect of obesity on neither employment probability nor wages.

Finally, Pinkston (2012) is the first paper to consider effects of body mass on wages in a dynamic panel data model and uses fixed effects estimation to account for the endogeneity of body mass. This framework allows the author to consider the effects of both current and past BMI, while also controlling for past wages. Estimation results suggest that past levels of body mass negatively affect the wages of young workers more than current BMI and this is especially true for white men. The only evidence of an effect of current weight is a penalty faced by morbidly obese women. This finding support the focus of Han et al. (2008) on the indirect effects of body mass on wages.

More recently, economists have started studying the relationship between weight excess and academic and cognitive achievements. The issue has been investigated at different ages, from early childhood to university-age students and also in this case it is possible to distinguish between researches establishing a simple correlation and those looking for a causal effect, this latter category being a minority.

Cawley and Spiess (2008) evaluated skill attainment in children from 2 to 4 years old, finding that, among boys, obesity is associated with reduced verbal, social and motor skills, while for girls is associated only with reduced verbal skills.

The link between weight excess and the academic performance of U.S. elementary school children was examined by several authors. Datar, Sturm and Magnabosco (2004) studied the association between children's overweight status in kindergarten and their academic achievement in kindergarten and first grade. Overweight children had significantly lower math and reading test scores compared with non-overweight peers in kindergarten and at the end of grade 1. However, these differences, except for boys' math scores became insignificant after controlling for socioeconomic and behavioral variables. This result seems to suggest that overweight is a marker but not a causal factor: ethnicity, mother's education and home environment were stronger predictors of test score than the overweight status.

Similar results are obtained by Datar and Sturm (2006), who focused on several outcomes: math and reading standardized test scores, school absences, grade repetition. They showed that change in overweight status during the first 4 years in school is a significant risk factor for adverse school outcomes among girls but not boys.

Different findings are obtained by Kaestner and Grossman (2009) using a sample of U.S. children's between the ages of 5 and 12 and the Peabody Individual Achievement Tests in math and reading as an outcome. Their results suggest that, in general, overweight or obese children get achievement test scores that are about the same as children with average weight

Focusing the attention on young adolescents, Mo-Suwan, Lebel, Puetpaiboon and Junjana (1999) showed, using a sample of Thai students, that being or becoming overweight during adolescence (grades 7-9) was associated with poor school performance. However, such an association did not exist using a two-years lagged value of BMI.

A sample of U.S. school-age children and adolescents is instead used by Li, Dai, Jackson and Zhang (2008) to study the associations between academic performance, cognitive functioning, and increased BMI. While the association between BMI and academic performance was not significant after adjusting for parental and family characteristics, the one between cognitive functioning remained significant after adjusting for familiy background, physical activity, hours spent watching TV and some health and psychosocial indicators.

Sigfusdottir, Kristjansson and Allegrante (2007) explored the relationship between health behaviours and academic achievement in Icelandic 14- and 15-year old students. Body mass index, diet and physical activity explained up to 24% of the variance in academic achievement when controlling for gender, parental education, family structure and absenteeism.

On the contrary, Kaestner, Grossman and Yarnoff (2009) using as outcomes highest grade attended, highest grade completed and drop out status, found that, in general, overweight or obese U.S. adolescents (between the ages of 14 and 18) have levels of attainment that are about the same as teens with average weight.

Contrasting results are obtained also by studies focusing on high school students.

Fuxa and Fulkerson (2011) found, using a sample of Minnesota students, that overweight and obese adolescents were significantly less likely to plan to go to college, more likely to report skipping school, lower academic grades and negative perceptions about the social environment and safety in school than non-overweight peers. Okunade, Hussey, Karakus (2009) suggest no adverse impact of overweight or obesity on timely high school completion for males, but a significant average negative effect on females, in particular white and Asian females. No significant effects were found for African-Americans. Finally, according to Karnehed et al. (2006), 18 years old Swedish obese students were ½ as likely to get into higher education.

Even if several researchers investigated the potential link between weight problems and educational or cognitive achievements, only few studies have focused on the causality of this relationship. These works tipically employ an instumental variable approach to face the endogeneity problem that is likely to affect individuals' BMI. Among them, we can distinguish between studies using a relative's BMI as IV and those using genetic markers.

In the former cathegory there is Sabia (2007), who studied the relationship between body weight of U.S. adolescent and their academic achievement to understand whether early human capital accumulation is adversely influenced by obesity.

He found consistent evidence of a significant negative relationship between BMI and grade point average in math and English language for white females aged 14-17. Instead, for non-white females and males, there was less convincing evidence of a causal link between body weight and academic performance after controlling for unobserved heterogeneity.

The main problem of this paper is the use of subjective and self-reported measures of parental obesity. Indeed, the variables used as instruments are neither parents' BMI levels nor dummies indicating whether they actually are overweight or obese, but rather variables stating whether they *feel* obese or not. Therefore, they inform about parents' *perceived* obesity, being not objective measures of their real weight status. Moreover, grade point averages are self – reported by students that may have an incentive to over-report their grades.

A second study using relatives weight status as an IV is Averett and Stiefel (2007) that focused on two types of childhood malnutrition: not only overweight but also underweight They use a sample of 5-years old children from the NLSY79 to investigate the cognitive consequences of child malnutrition, concluding that malnourished children tend have lower cognitive abilities when compared to well-nourished children.

Unfortunately, because of the lack of information in their dataset, they can rely only on maternal BMI as an IV, so that they cannot perform an overidentification test to check the validity of the instrument.

The literature using genetic markers in order to recover identification includes Fletcher and Leherer (2008), Norton and Han (2008), Ding et al. (2009) and Von Hinke Kessler Scholder et al. (2010).

The latter study is the only one using a U.K. dataset, the Avon Longitudinal Study of Parents and Children[3] (ALSPAC), and moves a critique to previous researches. As the authors pointed out, there is a week and inconsistent evidence in the medical literature that the genetic variants employed in the prior studies are robustly associated with fatness in large population samples. This is a serious problem since weak association may result in biased estimates.

Moreover, even if a suitable and robust genetic instrument is available, it may explain little of the variation in observed phenotype: if the alleles shift the adiposity distribution by a very small amount, the effect of fatness on test scores is identified only by this small difference in mean adiposity.

The variants used by Von Hinke Kessler Scholder et al. (2010) are currently the best candidates to be used as genetic markers, since they have been shown to be associated with adiposity in large population samples. However, the authors admit that, while their instruments are not weak in a statistical sense, their effects may be "too small to impact on the possible pathways to academic performance", concluding that genetic instruments should be used with care. Taking into account these observations, it is not surprising that none of these studies find a significant effect of fatness on academic performance.

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[3] The ALSPAC dataset collects information about a cohort roughly 14.000 children born in one geographic area of England, the Avon, between April 1991 and December 1992.

We want to shed new light on the causality of the link existing between weight problems and individual’s cognitive skills and we contribute to this literature using data from the British Cohort Study of 1970 (BCS70). This dataset contains information on *both* parents’ BMI: the use of two instrumental variables guarantees an efficiency gain in the estimation and allows us to perform an overidentification test on our instruments. This was not possible in all of the previous studies, using just one relative’s BMI as an IV for the individual’s BMI.

Moreover, the BCS70 allows us to control for many important variables (such as birthweight, whether the individual was breastfeeded when infant, his/her current psychological condition, parental education and school sentiment, etc.) that were often missed in the above mentioned studies.

Finally, we focus in the same paper on three different outcomes: a cognitive test performed in childhood, the later education attained and a literacy and numeracy skills test carried out in adulthood. This latter outcome is of particular interest, since most of the previous economic literaure about this topic have focused only on children and adolescents.

The panel structure of our data provide us two different observations of individuals’ BMI, one in 1980, when cohort members are 10 years old and the other in 2004, when they are 34. Therefore, in addition to the effect of current BMI on each of the tests, we can study both the impact of lagged Body Mass and the implications of a change in the weight status (from childhood to adulthood) on the test performed in 2004.

Table 1 – Studies investigating the consequences of obesity on economic outcomes

Paper	Data	Outcome	IV	Main Finding
Sargent and Blanchflower (1994)	UK	Wages	-	Negative association between obesity at 16 years and wages at 23 years for women but not for males
Han, Norton and Powel (2009)	USA	Wages	-	Negative correltion between late teen BMI and future wages
Averett and Korenman (1996)	U.S.A.	Family income and hourly pay	-	Evidence of lower family income and labor market discrimination against obese women
Cawley and Danziger	U.S.A.	Wages, employment probability and hours worked	-	Significant negative correlation between weight and labor market outcomes for white women
Cawley (2000)	USA	Employment disability	BMI of a biological child	Negative effect of obesity
Cawley (2004)	USA	Wages	BMI of a sibling	Negative effect of obesity for certain ethnic/gender groups
Brunello and D'Hombres (2005)	EU	Wages	Average of relatives' (siblings, parents, sons) BMI	Negative effect of obesity
Norton and Han (2008)	USA	Wages and employment probability	Genetic markers	No effect of obesity
Pinkston (2012)	USA	Wages	Lagged BMI in an AR model	Negative effect of lagged BMI on current wages

Table 2 – Studies investigating the consequences of obesity on educational and cognitive achievements

Paper	Data	Outcome	IV	Main Finding
Cawley and Spiess (2008)	Germany	Skill attainment in 2-4 years children	-	Obesity is associated with reduced verbal, social and motor skills for males and with reduced verbal skills for females
Datar, Sturm and Magnabosco (2004)	USA	Maths and reading test scores	-	Significant association between obesity and lower math and reading test scores in kindergarten and first grade children
Datar and Sturm (2006)	USA	Maths and reading test scores, school absenteism and grade repetition	-	Obesity is a significant risk factor for adverse school outcomes among elementary school girls
Kaestner and Grossman (2009)	USA	Maths and reading test scores	-	Obese children achievements are about the same of normal-weight peers
Li, Dai, Jackson and Zhang (2008)	USA	Academic performance and cognitive functioning	-	Negative effetc of obesity on school-aged children and adolescents' cognitive functioning but not on their academic performance
Sigfusdottir et al. (2007)	Iceland	Academic achievements		BMI, diet and physical activity explain a significant part of the variance in adolescents' academic achievements
Kaestner et al. (2008)	USA	Highest grade attended, highest grade completed and drop out rates	-	No significant effect of adolescent obesity on future academic outcomes
Fuxa and Fulkerson (2011)	USA	College enrolment	-	Overweight dolescents are signigicantly less likely to plan to go to college
Okunade et al. (2009)	USA	Timely high-school completion	-	Adverse impact of overweight and obesity on timely high-school completion for females but not for males.
Sabia (2007)	USA	Self-reported GPA in maths and English language	Parents' perceived obesity	Negative effect of obesity for white females
Averett and Stiefel (2007)	USA	Cognitive ability test score	Mother BMI	Negative effect of obesity and underweight
Fletcher and Leherer (2008)	USA	GPA + verbal test	Genetic markers	No effect of obesity
Ding, Weili, Lehrer and Rosenquist (2009)	USA	(Self-reported) GPA	Genetic markers	Negative effect of obesity for females but not for males
Von Hinke Kessler Scholder et al. (2010)	UK	KS3 score (english, math, science)	Genetic markers	No effect of obesity

3. Data and summary statistics

We use data from the British Cohort Study (BCS70), a longitudinal dataset collecting information on the births and families of babies born in England, Scotland, Wales and Northern Ireland in a particular week in April 1970 and following their lives until nowadays. Since the birth survey there have been seven "sweeps" of cohort members at ages 5, 10, 16, 26, 30, 34 and 38. In our analysis we focus the attention mainly on the 2nd and 6th sweeps: in the 2nd, carried out in 1980, cohort members are required to sit the British Ability Scale (B.A.S.) Test, while in the 6th sweep (2004) they take a literacy and numeracy skills examination. After having assessed the effect of current BMI on the two test scores, we study the impact of past weight status on the 2004 test score and the consequences of weight gain from childhood to adulthood. Data about cohort members' BMI are available also at the age of 16 but only for a subsample of teenagers.

The strenght of the BCS70 is the vast amount of information it provides about cohort members' environment, family background, educational attainment, socio-economic and heath status. This characteristic allows us to control for a large set of covariates in our regressions.

Our sample consists of 4368 individuals, among which 2055 are males and 2313 females.

As it can be seen from Table 3, in adulthood, weight problems are more severe among men: average BMI level, overweight and obesity rates are considerably greater for males. The data presented in the table could appear surprisingly hight (more than 61% of the male population is overweight) but they are perfectly in line with those from "The Health Interview Surveys", carried out by Eurostat in 2008.

The situation is different when we look at the weight statistics in 1980, during cohort members' childhood: the average BMI level is higher for females (this is due to their physilogical earlier growth) and the overweight and obesity rates are substantially equal between genders.

Table 3 – Weight conditions

	Mean	**Std. Dev.**	**Observations**
BMI 2004	25.77	4.75	4368
BMI 2004 males	26.64	4.34	2055
Overweight rate	61.65%		1267
Obesity rate	17.86%		367
BMI 2004 females	25.01	4.96	2313
Overweight rate	38.82%		898

Obesity rate	14.61%		338
BMI 1980	16.90	2.07	4368
BMI 1980 males	16.75	1.91	2055
Overweight rate	15.13%		311
Obesity rate	5.01%		103
BMI 1980 females	17.02	2.20	2313
Overweight rate	15.05%		348
Obesity rate	5.02%		116
Weight Trends			
Males			
Switch from non-overweight in 1980 to overweight in 2004	56.94%		993
Overweight in 1980 and in 2004	88.1%		274
Non-Overweight in 1980 and in 2004	43.06%		751
Overweight in 1980 but not in 2004	11.9%		37
Females			
Switch from non-overweight in 1980 to overweight in 2004	33.03%		649
Overweight in 1980 and in 2004	71.55%		249
Non-Overweight in 1980 and in 2004	66.97%		1316
Overweight in 1980 but not in 2004	28.45%		99

Looking at the weight evolution over time it can be noticed that almost 57% of males switch from a normal weight condition when 10 years old to the overweight status at the age of 34, while only 33% of females change ther weight cathegory over time in this direction.

In addition, overweight male children are also more likely to become overweight adults: 88% of overweight children suffer from weight problems also in adulthood, against 71.5% of females. These different trends in the weight evolution across genders explain the gap in the adult overweight and obesity rates, starting from a situation of almost equality.

The British Ability Scales has long been established as a leading standardised test in the UK for assessing a child's cognitive ability and educational achievement across a wide age range. The test version sit by cohort members in 1980 consists of four sections: word definition (explain the meaning of some given words), verbal similarities (tell a word that is related to three words told by the examinator), recall of digit (remember a progressively increasing number of digits) and matrices (complete some patterns drawing the appropriate shape in an empty square), for a total of 120 questions.

The Basic Skill Test sit by cohort members when they are 34 years old is, instead, divided into two sections: a literacy part, made up of 37 questions and a numeracy one, composed by 23 questions.

Table 4 – Test Scores

	Mean	Std. Dev.	Observations
B.A.S. TEST, 1980			
Test Score	63.69	11.71	3699
Males Test Score	64.20	12.09	1718
Females Test Score	63.25	11.36	1981
Score per Weight Cathegories			
Males, 1980			
Test Score if Normal Weight	64.03	12.07	1459
Test Score if Overweight	65.18	12.17	259
Test Score if Obese	65.98	11.95	83
Difference in mean: Normal vs Overweight	-1.15		
Difference in mean: Normal vs Obese	-1.95		
Females, 1980			
Test Score if Normal Weight	63.40	11.49	1698
Test Score if Overweight	62.34	10.48	283
Test Score if Obese	62.23	11.40	92
Difference in mean: Normal vs Overweight	1.06		
Difference in mean: Normal vs Obese	1.17		
BASIC SKILL TEST, 2004			
Test Score	50.83	7.17	4368
Males Test Score	51.57	7.09	2055
Females Test Score	50.17	7.18	2313
Score per Weight Cathegories			
Males, 2004			
Test Score if Normal Weight	51.97	7.11	788
Test Score if Overweight	51.32	7.07	1267
Test Score if Obese	51.19	7.11	367
Difference in mean: Normal vs Overweight	0.65**		
Difference in mean: Normal vs Obese	0.78*		
Females, 2004			
Test Score if Normal Weight	50.81	6.85	1415
Test Score if Overweight	49.15	7.56	898
Test Score if Obese	48.86	7.70	388
Difference in mean: Normal vs Overweight	1.66***		
Difference in mean: Normal vs Obese	1.95***		
Males, 1980			
Test Score if Normal Weight	51.61	7.04	1744
Test Score if Overweight	51.33	7.41	311
Test Score if Obese	50.86	7.83	103
Difference in mean: Normal vs Overweight	0.28		
Difference in mean: Normal vs Obese	0.75		
Females, 1980			
Test Score if Normal Weight	50.15	7.21	1966
Test Score if Overweight	50.28	7.02	347
Test Score if Obese	49.49	8.10	116
Difference in mean: Normal vs Overweight	-0.13		
Difference in mean: Normal vs Obese	0.66		

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$

The total score is given by the number of correct answers (there is no penalty for wrong answers). Hence, the test score is an integer number between zero and 60.

As it can be seen from Table 4, males performed, on average, slightly better than females in both the tests. What is of interest in our context is to compare test results across weight cathegories. Concerning the B.A.S score we can observe opposite trends in the two genders: the score increases with BMI among males, while it decreases among females.

In the basic skill test the trend is instead the same in both sexes: the score decreases as the weight increseas. This inverse relationship holds not only for both genders but also for both the ages considered (10 and 34), with the only exception of overweight females children, that, when adult, performed sligthly better than non-overweight peers. However, when weight problems are more severe, resulting in obesity, the trend is restored, with obese female children performing significantly worser than nomal-weights.

4. Empirical Models and Estimation Strategies

OLS Model

Following the literature on the effects of Body Mass on individuals' outcomes, we assume that our regression of interest takes the form:

$$y_i = \alpha + \beta BMI_i + \gamma X_{1i} + \delta X_{2i} + \varepsilon_i \qquad (1)$$

where y_i is the test score reported by individual i in either the B.A.S or the Basic Skills tests, BMI_i is the cohort member Body Mass Index and X_{1i} and X_{2i} are two vectors of control variables. The former includes individual-level and family-level observables, such as years of schooling, birth and living country, family income, parents' education and so on, while the latter collects information about the family cultural environment and parental attitudes towards children schooling. The complete list of control variables is provided in Appendix A.

The estimate of β will be an unbiased estimate of the effect of Body Mass on individuals' basic skills only if there are no unobservable characteristics correlated with both BMI and test score, that is $E(\varepsilon|BMI)$=0. If this identification assumption is violated, as it is the case in presence of endogeneity or unobserved heterogeneity, our OLS estimate of β will be biased.

We estimate equation (1) using each test scores as dependent variables and individuals' BMIs as regressors, in order to study the current and lagged effects of Body Mass.

Then, we move our attention from the continuos variable BMI to a dummy variable indicating whether the CM suffers from weight problems, estimating the following equation:

$$y_i = \alpha + \beta overweight \,\&\, obesity_i + \gamma X_{1i} + \delta X_{2i} + \varepsilon_i \qquad (2)$$

Also in this case, for the Basic Skills test sit in 2004, we focus on the individuals' weight status at 10 and 34 years old.

Finally, in order to investigate the potential effects of weight gain from childhood to adulthood, we create some dummy variables indicating whether CMs have changed their weight classification, from 1980 to 2004, moving from a normal-weight condition to overweight.

In this case, the model to be estimated is:

$$y_i = \alpha + \beta D_i + \gamma X_{1i} + \delta X_{2i} + \varepsilon_i \qquad (3)$$

where y_i is the outcome of the Basic Skills Test and D_i is a vector of contol variables indicating whether the CM became overweight, slimmed down or stayed overweight. We use individuals who are normal weight both in 1980 and 2004 as the reference cathegory.

IV Models

As pointed out before, the OLS estimates are unbiased only in the absence of endogeneity and unobserved heterogeneity issues. This is hardly the case in our context: reverse causality may take place since individuals' skills could affect their Body Mass, influencing their diets and lifestyle choices or creating phychological discomfort. As already mentioned, stress can alter eating habits inducing individuals to consume less (or more) food than needed.

The presence of unobservable characteristics, both at the individual and family level, could also biased our results.

A common method for addressing these problems is the use of instrumental variables. This requires finding at least one observable variable that provide exogenous variation in individuals' BMI but is uncorrelated with the outcome of interest except through BMI iteself.

Following the literature (e.g. Cawley 2000 and 2004; Brunello and d'Hombres 2005) we choose as instruments for model (1) the BMI of a relative. In particular, we are the first ones in this kind of literature that can exploit information on both parents' Body Mass. This allow us to perform an overidentification test, that support the validity of our choice.

Parental BMI is likely to satisfy the first requirement for IVs, since it is strongly correlated with that of their offsprings: Comuzzie and Allison (1998) estimated that 40 to 70 percent of the variation in obesity-related phenotypes in humans is heritable, while Castelnovo (2013) highlighted the influence that parental BMI has on offspring's BMI and computed intergenerational elasticities. Moreover, parents' body mass must be uncorrelated with unobservables determinants of cognitive skills, that is with the error term ε. As highlighted by Cawley (2004) and Sabia (2007) there is medical evidence[4] from studies using samples of adoptees suggesting that genetics rather than household environment is the most important determinant of body weight. This support the use of biologically related individuals' BMI as a credible instrument.

Following the same reasoning, the instruments chosen for model (2) are two dummy variables telling whether parents are overweight/obese or not..

As we will see in the next section, all of the tests we have performed in order to assess the validity of our instruments give satisfactory results.

However, given the concerns of their potential correlation with household attitudes toward education, following Sabia (2007), we control for several measures of "family-level school sentiment" and parents' general propension to "intellectual" activities, such as reading newspapers or books. These are the control variables we included in the vector X_{2i}.

Since in model (2) the endogenous regressor is a dummy variable, we estimate the model parameters applying four different estimation strategies.

First, we apply the standard 2SLS procedure, where we estimate the first-stage equation by means of a probit model and then we apply OLS in the second-stage.

The second strategy employed is maximun likelihood.

Finally, we apply the Heckmann correction (or Heckmann two-steps method), assuming first homogeneus treatment effects (Endogenous Dummy Model) and then allowing for heterogeneuos effects (Endogenous Switching Model). In both the cases, the treatment is given by the overweight/obesity condition. Hovewer, the two models rely on different assumptions. In the Endogenous Dummy Model the treatment effect is assumed to be homogeneous in the population, that is the idiosyncratic gain is zero for every individual. In other words, the impact of the treatment does not vary with individuals' observable characteristics and the unobservable determinants of the outcome are the same with or without treatment. Moreover, it is assumed that the error terms of the outcome and selection equations are distributed as a Multivariate Normal.

Then, we relax the strong homogeneous effect assumption using an Endogenous Switching Model, where we allow for heterogeneuos treatment, that is for individual-specific effetcs: the average treatment effect (ATE) is allowed to vary across individuals with different observable characteristics and to affect the probability of individuals to "choose" the treatment.

[4] See Stunkar et al. (1986), Grilo and Pogue-Geile (1991) and Vogler et al. (1995).

5. Results

5.1 OLS Estimates

We start by analyzing the effect of BMI in 1980 on the B.A.S. score, first using the overall sample and then for males and females separately.

The results of the OLS estimates are reported in Table 5, Appendix D. The coefficients in columns (1) are those from the univariate regression of the test score on individuals' BMI. The specification in columns (2) includes the set of control variables contained in the X_{1i} vector, while in columns (3) we control also for parental attitudes towards education. The coefficients of the regressors of main interest are presented in Appendix B.

In each of the model specifications in which our set of controls are included, we find no significant association between cognitive ability and individuals' BMI.

Then, we consider the effect of current Body Mass on the Basic Skill Test sit in 2004 (Table 6). Looking at the whole sample, the OLS estimates are negative and significant in all of the model specifications: one unit increase in individuals' BMI is associated to a test score reduction of 0.088 points (out of 60) in the univariate model and of about 0.05 points in the two other specifications.

However, when we distinguish between males and females, this association turns out to be significant only for females and the score reduction is of about 0.07 points..

On the contrary, using lagged BMI levels, we don't find any significant relationship, neither in the whole sample nor separating by sex (Table 7).

Hence, from our OLS results, it seems that no relationship between body weight and cognitive ability exists during childhood, while deficincies in basic skills are associated with increased Body Mass in adulthood but not in childhood.

This could appear surprising, since we might expect overweight in childhood be more detrimental for individuals' literacy and numeracy skills since it affects individuals during the educational process, when human capital accumulation is taking place.

The different relationship between skills and Body Mass at different ages could be due to a difference in weight distributions: plotting BMI densities in 1980 and 2004 we can notice relevant differences (Appendix C). [EXPLAIN BETTER]

Therefore, we decide to move our attention from the continuous BMI variable to a dummy indicating whether individuals suffer from weight problems. To this aim, we adopt the International Obesity Task Force classification, according to which adult individuals are classified as overweight if their BMI is greater or equal to 25.

As it can be seen from Table 8, belonging to this weight cathegory in 2004 is strongly associated with a decrease in basic skills for females but not for males.

The classification into the overweight status is slightly more complicated when we consider cohort members at 10 years old. According to the medical literature, for children it is necessary to distinguish between males and females and the assignment to a weight cathegory is done looking at the relative position in the sample weight distribution. In particular, a child is classified as overweight if his/her BMI belongs to the 85th percentiles or higher.

However, even following this approach we find no statistically significant relationship between individuals' weight in 1980 and the test score reported in 2004 (Table 9).

The same result holds when we look at the effect of weight excess in 1980 on the B.A.S. score (Table 10).

Therefore, the findings obtained using the overweight/obesity dummy are perfectly in line with those previously found for the continuos variable BMI.

In order to better understand the different impact of overweight at different ages on the literacy and numeracy skills test, we decide to face this issue from a dynamic point of view, focusing on individuals' weight evolution over time.

Indeed, looking at the summary statistics presented in Table 3 we notice that overweight rates are much higher in adulthood than in childhood (about 50% vs 15%). Data about weight transition over time confirms that many cohort members move from a normal weight condition when 10 years old to the overweight status at the age of 34. We create dummy variables to identify individuals that become overweight, stay overweight or slim down and study whether weight transition over time is associated with a test score reduction[5].

Since the starting age from which we measure the change in Body Mass cathegory is childhood, we have to perform the analysis separately for males and females.

As it can be seen from Table 11, weight gain is strongly associated with a lower basic skill level at age 34 for females, but not for males, at least when we include our controls in the regression.

In the univariate regression, becoming overweight is associated with a test score reduction of about 0.6 points (out of 60) for males and 2 for females, while when including all our controls the reduction is of about 1.2 points for females and there is no statistically significant effect for males.

[5] Reference cathegory is given by individuals that are normal-weight in both 1980 and 2004.

On the opposite, even if their signs are in the expected direction, the coefficients of the dummies for staying overweight and slimming down from overweightness to a normal-weight are never statistically significant.

5.2 IV Estimates

Following the previous literature, we instrument individual BMI with that of biological family members. In particular, we can exploit information on both cohort members' parents, so that we can rely on two instruments. Our IV results are shown in Appendix E.

Again, we start by focusing on the B.A.S. test. IV coefficients are always negative, significant and larger in size than OLS ones. In particular, in our preferred model specification (columns 3), they are 10% significant and about 5 times greater (in absolute value) than OLS ones for males and 1% significant and about 20 times greater for females (Table 12).

This is in line with the field literature: increase of comparable size are found, when instrumenting, by Sabia (2007), Brunello and d'Hombres (2005), Averett and Stiefel (2007) and Cawley (2004), at least for some, if not all, the population subgroups they considered.

According to our IV results, one unit increase in individuals' BMI causes an average test score reduction of about 1.10 points out of 120 for males and 1.38 for females.

One possible explanation for this raise in coefficients' size is that OLS estimates are biased upwords by the positive correlation between unobservables, such as motivation or perseverance, and the BMI: overweight and obese individuals compensate their weight with unobservables characteristics that improve their skills.

Similar results hold when we consider the Basic Skill Test. Using 2004 Body Mass as a regressor (Table 13), IV coefficients are negative, like OLS ones, but highly significant for both sexes and not just for females. Again, they also increase in magnitude. The raise is now larger for males than for females: it is of about 55 times for the former and 3.5 times for the latter. One unit increase in 2004 average BMI causes a reduction of 0.55 points out of 60 in the average males' score and of 0.27 points in the females' one.

When looking at the effect of lagged BMI (Table 14), we observe a change in coefficients' sign and significance with respect to OLS estimates[6]: the effect of 1980 Body Mass becomes negative and highly significant. The increase in size is in absolute value much greater than the one of current BMI. According to our IV estimates, a unitary increase in average Body Mass in 1980 leads to an average test score reduction of about 1.2 points for males and 0.65 for females.

[6] The same change in coefficients' size can be found in Brunello and d'Hombres (2005) for the male population.

Therefore, contrary to OLS results, it seems that high BMI levels are more penalizing when recorded during childhood, that is in the meanwhile of the educational process. This is in my opinion a reasonable finding, since it is during the human capital accumulation process that obesity may influence more seriously skills acquisition.

All of the tests performed to check the goodness of our instruments are satisfied[7]: the high p-value of the Sargan over-identification test supports their validity (there is no correlation with the error term), while both the low p-value of the Anderson under-identification test and the high Cragg-Donald Wald F-statistic suggest that excluded restrictions are relevant, that is correlated with individual BMI, whose endogeneity is confirmed by the zero p-value of the endogeneity test performed.

Even if the instruments are strong predictors of body weight and satisfy the Sargan overidentification test, the quite low first-stage R^2 values raise some doubts about the presence of a weak instrument problem, resulting in size distortion.

When we move attention to weight cathegories, our results are in line with those obtained using the Body Mass as a regressor.

Looking at the Basic Skills Test and using information about the weight status in 2004 (Table 15), estimates accounting for endogeneity are, in the whole sample, about 8-9 times greater in absolute value with respect to OLS ones: being overweight or obese reduces (on average) the test score by about 5 points (out of 60).

Again, a possible explanation for the change in coefficients' size when we allow for endogeneity is that individuals suffering from weight problems compensate the negative effect of weight with unobservables characteristics, such as motivation and perseverance, biasing OLS estimate downwards.

It is important to notice that all the estimation strategies we used gave very similar results, suggesting evidence of a significant negative relation between current BMI and basic skills.

However, when distinguishing between males and females (Table 16) the outcomes of the different procedures are less homogeneus: the test score reduction ranges from about 4 to 6 points for males and from 4 to 5.5 points for females.

In Models (4) the coefficient associated to the Heckman correction term (*lambda*) is significant at 1% and positive, meaning that endogeneity concerns were justified and positive self-selection into treatment takes place. In other words, there is a positive correlation between unobservable characteristics, included in the error term, and the dependent variable,

[7] The only exception is given by the Sargan test results in the female sample when we use the overweight/obesity dummy as a regressor.

that is the score obtained in the basic skill test: obese people seem to have on average better unobserved characteristics than non-obese peers.

Similar results hold when we study the effect of weight excess in 1980 on the Basic Skills Test and on the B.A.S., but in these cases the negative impact of overweightness is even greater (Table 17 and 18).

6. Conclusions

In this paper we studied the relationship between Body Mass and two measures of cognitive and educational achievements: the British Ability Scale test, taken when individuals are 10 years old, and a literacy and numeracy test, sit at the age of 34.

The issue is of great relevance since cognitive ability and educational outcomes are important determinants of individuals' productivity and wages. Economists have indeed studied the link between obesity and economic outcomes like employment probability, work absenteism and wages finding that weight excess has a negative effect on them. However, they have not clarified the potential channels that can explain this relationship.

In our analysis we used as a sample a cohort of British individuals for which we have information about BMI in the years when the two tests are undertaken. In this way, for the second test, we are able to study both the current and lagged effects of Body Mass.

We started by analyzing the association between weight and tests' outcome and then we focused on the causal link between the two, following an instrumental variable approach.

According to our OLS estimates, a negative association exists between current BMI and the basic skills test score sit in 2004. However, when we distinguished between males and females, such relationship turned out to be significant only for the latters. In our preferred specification, one unit increase in females average BMI was associated to a test score reduction of about 0.07 points out of 60 (in the whole sample the reduction was of about 0.05 points).

On the contrary, we didn't find any significant association with lagged Body Mass and between the B.A.S. score obtained in 1980 and then BMI levels.

The subsequent OLS analysis carried out using weight cathegories instead of the continuos variable BMI confirmed all these results. Being overweight when sitting the basic skills test is associated to a decrease of about 0.9 points in females average test score (0.6 points in the overall sample).

However, our OLS results are likely to suffer from endogeneity and unobserved heterogeneity problems. In order to understand whether the effect of obesity is causal, we decided to use the instrumetal variable estimation method. Following Cawley (2000, 2004), Brunello and d'Hombres (2005), Sabia (2007) and Averett and Stifel (2007) we chose relatives' BMI as an IV. Contrary to previous studies, our dataset provides information on both parents' BMI and therefore we have an additional element to check our instruments' validity by means of an overidentification test.

Our IV estimates revealed the existence of a negative and statistically significant causal effect of current BMI on the outcome of both the B.A.S. and the Basic Skills tests. The effect was significant also for males (even if only at 10% in the B.A.S. test) and larger in absolute value with respect to OLS. A raise in coefficients' size was found, when instrumenting, by most of the above mentioned studies, at least for some the population subgroups considered. This increase can be explained by the presence of a positive correlation between unobservables, like motivation or perseverance, and the BMI, that makes OLS coefficients downward biased. Intuitively, overweight and obese individuals may compensate the negative effect of weight with characteristics, attitudes and behaviours that are unobservable to us and that can improve their skills. For example they might put more effort in their activities or devote more time to studying, maybe because they are less involved in social and sport activities.

As for OLS, the negative effect of weight is confirmed by the analysis carried out using a dummy that identifies overweight and obese individuals instead of using the continuos variable BMI.

Finally, exploiting the availability of BMI data at different ages, we studied the effect of weight gain over time, finding that moving from a normal-weight condition in childhood to overweightness in adulthood is associated with lower basic skills levels. Of course, in this case, reverse causality may still be an issue.

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Appendix A – List of Control Variables

The observables included in vector X_{1i} are:

- Years of schooling of the cohort member (CM)
- Sex of the CM
- Birth country of theCM
- Living country of the CM
- Ethnic group of the CM
- Years of schooling of CM's mother
- Years of schooling of CM's father
- Family income when CM was 10 years old
- Number of household members when CM was 10 years old
- Birthweight of CM
- Whether the CM was breast-feeded
- Whether the CM suffer from depression

The variables included in vector X_{2i} are dummies indicating whether:

- newspapers are usually available at home
- magazines or Sunday papers are usually available at home
- mother reads books or magazines
- father reads books or magazines
- parents help in homework
- parents have no expectation about school
- parents visit school
- mother is unable to help in homework
- father is unable to help in homework
- both parents unable to help in homework
- parents impose curfew in schooldays

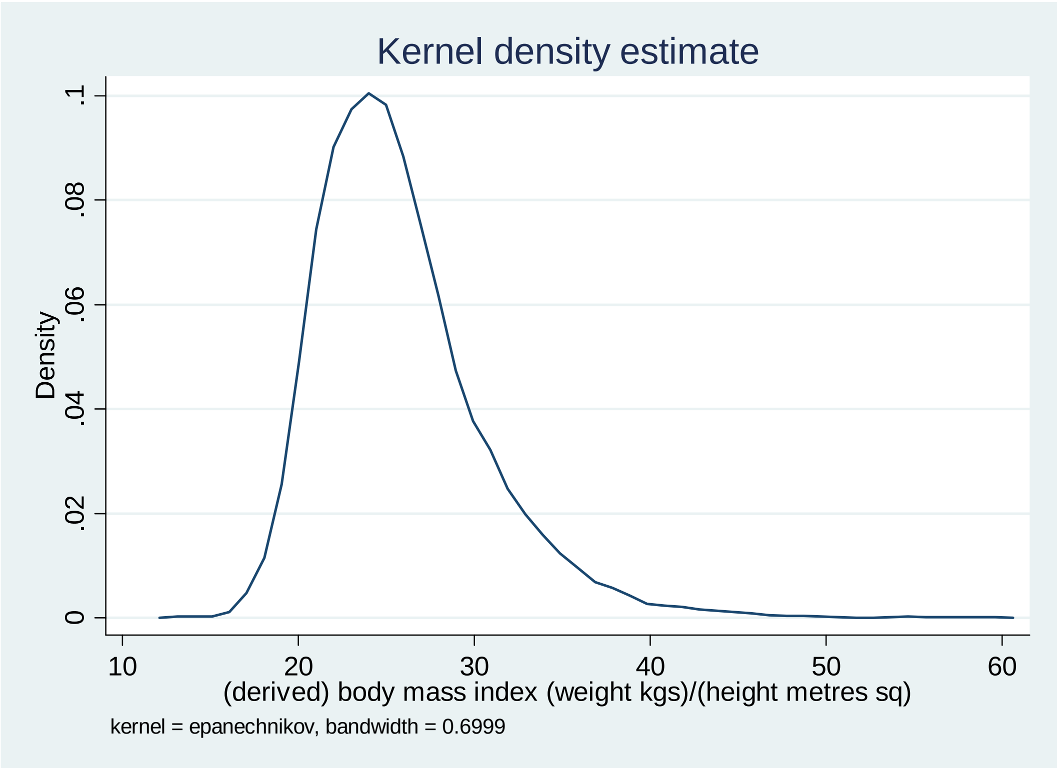
Appendix B – **Coefficients of the control variables of main interest (overall sample, specification 2)**

Variable	**Coefficient**	**t-stat**
Years of Schooling	0.412***	14.44
Sex	-1.389***	6.64
Mother's Years of Schooling	0.475***	7.05
Father's Years of Schooling	0.116**	2.46
Income: 1st racket	-2.333**	3.14
Income: 2nd racket	0.090	0.24
Income: 3rt racket	0.829**	2.09
Income: 4th racket	0.977**	2.10
Birthweight	0.001***	5.00
Breast-feeding	0.387*	1.86
Household Members	-0.670***	6.61

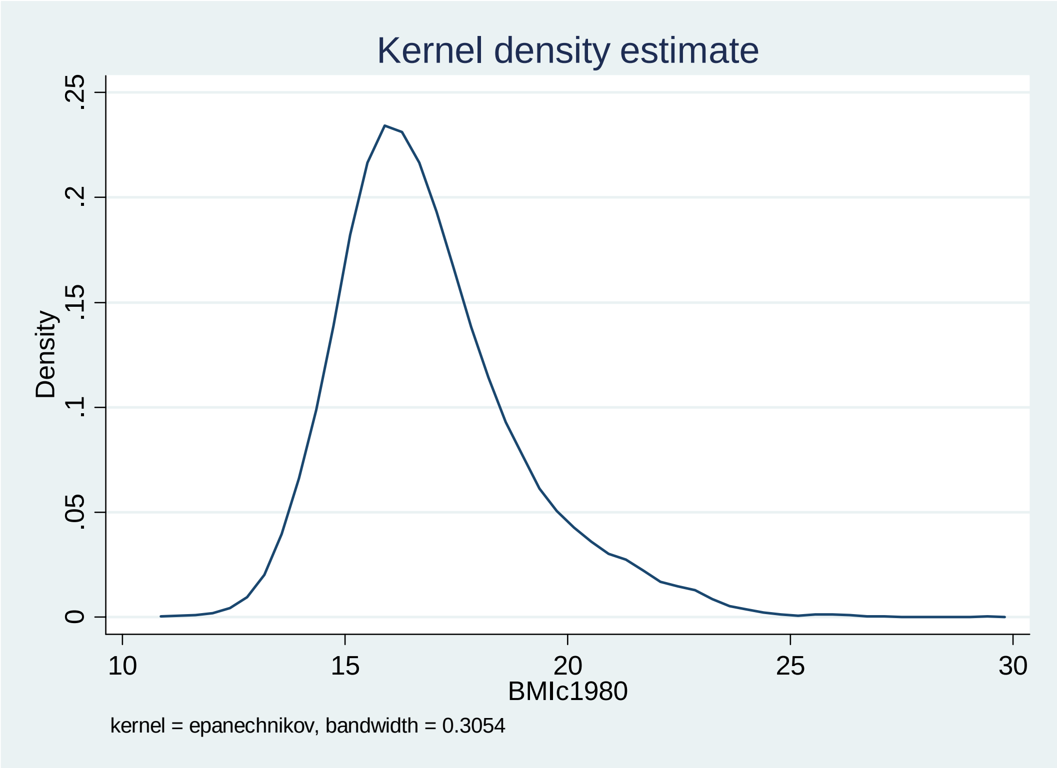
* p < 0.10, ** p < 0.05, *** p < 0.001

Appendix C – **BMI distributions**

BMI distribution in 2004



BMI distribution in 1980



Appendix D – OLS Tables

Table 5 – Effect of BMI on the B.A.S. score

	B.A.S. Test Score 1980								
	OVERALL			MALES			FEMALES		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
BMI 1980	0.037	0.030	0.049	0.322**	0.238	0.230	-0.123	-0.112	-0.063
	(0.39)	(0.33)	(0.55)	(2.02)	(1.56)	(1.51)	(1.07)	(1.01)	(0.59)
Controls in X_{1i}		X	X		X	X		X	X
Controls in X_{2i}			X			X			X
Cons	63.07	44.18	43.85	58.82	39.97	41.12	65.35	46.00	41.95
	(30.10)	(16.25)	(15.55)	(21.87)	(10.24)	(9.68)	(32.86)	(12.23)	(11.15)
N	3699	3675	3675	1718	1704	1704	1981	1971	1971

t statistics in parentheses;
* p < 0.10, ** p < 0.05, *** p < 0.001

Table 6 - Effect of current BMI on the Basic Skill Test score

	Basic Skills Test Score 2004								
	OVERALL			MALES			FEMALES		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
BMI 2004	-0.088***	-0.051**	-0.046**	-0.066*	-0.011	-0.010	-0.151***	-0.079**	-0.074**
	(3.15)	(2.16)	(1.99)	(1.83)	(0.33)	(0.30)	(5.05)	(2.83)	(2.66)
Controls in X_{1i}		X	X		X	X		X	X
Controls in X_{2i}			X			X			X
Cons	53.09 ***	47.17***	44.79***	53.32***	44.05***	43.12***	53.94***	38.84***	34.18***
	(83.46)	(30.51)	(31.96)	(54.77)	(8.62)	(8.53)	(70.69)	(19.59)	(18.04)
N	4368	4340	4340	2055	2039	2039	2313	2301	2301

t statistics in parentheses;
* p < 0.10, ** p < 0.05, *** p < 0.001

Table 7 - Effect of lagged BMI on the Basic Skill Test score

	Basic Skills Test Score 2004								
	OVERALL			MALES			FEMALES		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
BMI 1980	0.015	0.028	0.047	0.079	0.056	0.036	0.009	0.028	0.042
	(0.20)	(0.49)	(0.88)	(0.97)	(0.72)	(0.46)	(0.13)	(0.44)	(0.68)
Controls in X_{1i}		X	X		X	X		X	X
Controls in X_{2i}			X			X			X
Cons	50.58***	47.71***	42.62***	50.24***	42.88***	44.13***	50.01***	36.15***	34.38***
	(51.58)	(28.58)	(30.29)	(36.32)	(8.36)	(8.61)	(42.91)	(17.16)	(16.41)
N	4368	4340	4340	2055	2039	2039	2313	2301	2301

t statistics in parentheses;
* p < 0.10, ** p < 0.05, *** p < 0.001

Table 8 - Effect on the Basic Skill Test score of being overweight in 2004

	Basic Skills Test Score 2004								
	OVERALL			MALES			FEMALES		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Overweight 2004	-0.81***	-0.64**	-0.59**	-0.66**	-0.26	-0.25	-1.66***	-1.01***	-0.93***
	(3.73)	(3.07)	(2.85)	(2.04)	(0.86)	(0.83)	(5.45)	(3.54)	(3.29)
Controls in X_{1i}		X	X		X	X		X	X
Controls in X_{2i}			X			X			X
Cons	51.23***	46.41***	46.69***	51.97***	44.02***	44.96***	50.81***	37.16***	35.61***
	(335.63)	(9.57)	(9.72)	(205.82)	(8.78)	(8.98)	(267.77)	(20.38)	(19.56)
N	4368	4340	4340	2055	2039	2039	2313	2301	2301

t statistics in parentheses;
* p < 0.10, ** p < 0.05, *** p < 0.001

Table 9 - Effect on the Basic Skill Test score of being overweight in 1980

	Basic Skills Test Score 2004					
		MALES			FEMALES	
	(1)	(2)	(3)	(1)	(2)	(3)
Overweight in 1980	-0.284	-0.154	-0.240	0.125	0.301	0.293
	(0.65)	(0.37)	(0.58)	(0.30)	(0.77)	(0.76)
Controls in X_{1i}		X	X		X	X
Controls in X_{2i}			X			X
Cons	51.61***	43.71***	44.66***	50.15***	36.55***	35.03***
	(303.78)	(8.74)	(8.94)	(309.52)	(20.05)	(19.26)
N	2055	2039	2039	2313	2301	2301

t statistics in parentheses;
* p < 0.10, ** p < 0.05, *** p < 0.001

Table 10 - Effect on the B.A.S. score of being overweight in 1980

	B.A.S. Test Score 1980					
		MALES			FEMALES	
	(1)	(2)	(3)	(1)	(2)	(3)
Overweight in 1980	1.15	1.16	1.06	-1.06	-0.84	-0.75
	(1.40)	(1.52)	(1.38)	(1.56)	(1.27)	(1.16)
Controls in X_{1i}		X	X		X	X
Controls in X_{2i}			X			X
cons	64.03	43.39	44.45	63.40	44.34	41.04
	(202.65)	(13.18)	(12.14)	(227.29)	(13.70)	(12.50)
N	1718	1704	1704	1981	1971	1971

t statistics in parentheses;
* p < 0.10, ** p < 0.05, *** p < 0.001

Table 11 – The impact of weight gain from childhood to adulthood

	Basic Skills Test Score 2004					
		MALES			FEMALES	
	(1)	(2)	(3)	(1)	(2)	(3)
Get overweight	-0.61*	-0.21	-0.18	-1.99***	-1.29***	-1.19***
	(1.77)	(0.66)	(0.56)	(5.83)	(4.03)	(3.75)
Slim down	0.34	0.35	0.32	0.07	0.15	0.16
	(0.28)	(0.31)	(0.29)	(0.10)	(0.21)	(0.23)
Stay overweight	-0.76	-0.36	-0.44	-0.77	-0.24	-0.21
	(1.52)	(0.76)	(0.92)	(1.56)	(0.52)	(0.45)
Controls in X_{1i}		X	X		X	X
Controls in X_{2i}			X			X
Cons	51.95***	43.99***	44.91***	50.81***	37.15***	35.60***
	(200.78)	(8.77)	(8.96)	(258.39)	(20.37)	(19.56)
N	2055	2039	2039	2313	2301	2301

t statistics in parentheses;
* p < 0.10, ** p < 0.05, *** p < 0.001

Appendix E – IV Tables

Table 12 - Effect of BMI on the B.A.S. score

	BAS Test Score 1980								
	OVERALL			MALES			FEMALES		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
BMI 1980	-2.70***	-1.33***	-1.25***	-2.55***	-1.13*	-1.10*	-2.75***	-1.48***	-1.38***
	(7.13)	(4.01)	(3.83)	(3.51)	(1.73)	(1.70)	(6.37)	(3.99)	(3.77)
Controls in X_{1i}		X	X		X	X		X	X
Controls in X_{2i}			X			X			X
Sargan Overid. Test p-value	0.380	0.400	0.220	0.510	0.284	0.452	0.064	0.023	0.011
Endogeneity Test p-value	0.000	0.000	0.000	0.000	0.028	0.030	0.000	0.000	0.000
Underid. Test p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cragg-Donald Wald F-stat.	151.51	147.78	146.81	49.40	45.53	45.21	100.82	100.96	98.84
R^2 first stage	0.076	0.094	0.095	0.055	0.076	0.079	0.093	0.108	0.114
Cons	109.26	63.10	62.06	106.88	59.42	60.14	109.93	68.23	63.44
	(17.09)	(6.72)	(6.71)	(8.78)	(4.69)	(4.78)	(14.98)	(9.93)	(9.31)
N	3699	3675	3675	1718	1704	1704	1981	1971	1971

t statistics in parentheses;
* p < 0.10, ** p < 0.05, *** p < 0.001

Table 13 - Effect of current BMI on the Basic Skill Test score

	Basic Skills Test Score 2004								
	OVERALL			MALES			FEMALES		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
BMI 2004	-0.69***	-0.39***	-0.37***	-0.78***	-0.52***	-0.55***	-0.60***	-0.31***	-0.27***
	(8.38)	(5.12)	(4.93)	(5.06)	(3.47)	(3.63)	(6.65)	(3.56)	(3.22)
Controls in X_{1i}		X	X		X	X		X	X
Controls in X_{2i}			X			X			X
Sargan Overid. Test p-value	0.742	0.717	0.565	0.625	0.515	0.593	0.384	0.223	0.153
Endog. Test p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Underid. Test p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.011
F-Test.	211.12	200.18	198.92	71.59	61.27	60.784	156.83	139.95	138.27
R^2 first stage	0.088	0.131	0.133	0.065	0.082	0.084	0.120	0.132	0.136
Cons	68.70	58.25	58.05	72.33	59.97	61.66	65.25	46.08	43.31
	(32.15)	(10.49)	(10.57)	(17.61)	(8.52)	(8.76)	(28.70)	(14.99)	(14.12)
N	4368	4340	4340	2055	2039	2039	2313	2301	2301

t statistics in parentheses;
* p < 0.10, ** p < 0.05, *** p < 0.001

Table 14 - Effect of lagged BMI on the Basic Skill Test score

	Basic Skills Test Score 2004								
	OVERALL			MALES			FEMALES		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
BMI 1980	-1.71***	-0.93***	-0.88***	-1.84***	-1.18***	-1.24***	-1.57***	-0.73***	-0.65***
	(8.04)	(5.00)	(4.81)	(4.89)	(3.44)	(3.61)	(6.13)	(3.37)	(3.02)
Controls in X_{1i}		X	X		X	X		X	X
Controls in X_{2i}			X			X			X
Sargan Overid. Test p-value	0.475	0.500	0.370	0.571	0.500	0.594	0.151	0.129	0.090
Endog. Test p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Underid. Test p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-Test	177.64	175.31	174.97	65.62	61.74	61.17	109.86	111.27	109.32
R^2 first stage	0.075	0.095	0.097	0.060	0.082	0.086	0.087	0.107	0.111
Cons	79.82	58.94	58.63	82.41	61.01	62.89	76.85	49.86	46.54
	(22.12)	(10.31)	(10.39)	(13.06)	(8.37)	(8.61)	(17.64)	(11.98)	(11.30)
N	4368	4340	4340	2055	2039	2039	2313	2301	2301

t statistics in parentheses;
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$

Table 15 - Effect on the Basic Skill Test score of being overweight in 2004 (OVERALL)

	Basic Skills Test Score 2004				
	(1) OLS	(2) IV	(3) MLE	(4) Endogenous Dummy Model	(5) Endogenous Switching Model
Overweight/Obesity in 2004	-0.586**	-5.14***	-4.66***	-4.97***	-4.89***
	(2.85)	(4.70)	(4.92)	(4.82)	
Controls in X_{1i}	X	X	X	X	X
Controls in X_{2i}	X	X	X	X	X
Sargan Overid. Test p-value		0.993			
Endogeneity Test p-value		0.000			
Underid. Test p-value		0.000			
F-Test.		87.007			
Λ				2.82***	
				(4.37)	
R^2 first stage		0.105			
Cons	46.69	45.23	44.69	45.09	
	(9.72)	(16.65)	(16.14)	(16.59)	
N	4368	4340	4340	4340	4340

t statistics in parentheses;
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$

Table 16 - Effect on the Basic Skill Test score of being overweight in 2004 (MALES vs FEMALES)

	Basic Skills Test Score 2004									
	MALES					FEMALES				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
	OLS	IV	MLE	Endog. Dummy Model	Endog. Switch. Model	OLS	IV	MLE	Endog. Dummy Model	Endog. Switch. Model
Overweight/Obesity in 2004	-0.25	-6.15***	-3.89***	-5.82***	-5.47	-0.93***	-4.45***	-5.62***	-4.22**	-4.06
	(0.83)	(3.49)	(3.18)	(3.32)	St.dev.: 1.65	(3.29)	(3.49)	(4.05)	(3.34)	St.dev.: 1.32
Controls in X_{1i}	X	X	X	X	X	X	X	X	X	X
Controls in X_{2i}	X	X	X	X	X	X	X	X	X	X
Sargan Overid. Test p-value		0.391					0.428			
Endogeneity Test p-value		0.001					0.005			
Underid. Test p-value		0.000					0.000			
F-Test.		30.02					57.93			
Λ				3.56***					2.11***	
				(3.27)					(2.67)	
R^2 first stage		0.051								
Cons	44.96***	44.19***	42.20***	43.96***		35.61***	38.85***	39.97***	38.58***	
	(8.98)	(12.77)	(12.56)	12.68		(19.56)	(9.02)	(8.79)	(8.98)	
N	2039	2039	2039	2039	2039	2301	2301	2301	2301	2301

t statistics in parentheses;
* p < 0.10, ** p < 0.05, *** p < 0.001

Table 17 - Effect on the Basic Skill Test score of being overweight in 1980 (MALES vs FEMALES)

	Basic Skills Test Score 2004									
	MALES					FEMALES				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
	OLS	IV	MLE	Endog. Dummy Model	Endog. Switch. Model	OLS	IV	MLE	Endog. Dummy Model	Endog. Switch. Model
Overweight/Obesity in 1980	-0.240	-7.83***	-9.61***	-6.17**	-8.23	0.293	-6.45***	-9.52***	-4.27**	-2.73
	(0.58)	(4.42)	(16.77)	(2.55)	St. Dev.: 2.49	(0.76)	(4.61)	(17.70)	(2.37)	St. Dev.: 2.06
Controls in X_{1i}	X	X	X	X	X	X	X	X	X	X
Controls in X_{2i}	X	X	X	X	X	X	X	X	X	X
Sargan Overid. Test p-value		0.391					0.427			
Endogeneity Test p-value		0.000					0.005			
Underid. Test p-value		0.000					0.000			
F-Test.		30.02					57.93			
Λ				3.35**					2.62***	
				(2.49)					(2.60)	
R^2 first stage										
Cons	44.66***	39.30***	39.06***	38.91***		35.03***	41.33***	37.99***	36.03***	
	(8.94)	(16.23)	(11.39)	(12.64)		(19.26)	(16.74)	(8.15)	(8.63)	
N	2039	2039	2309	2039	2039	2301	2301	2301	2301	2301

t statistics in parentheses;
* p < 0.10, ** p < 0.05, *** p < 0.001

Table 18 - Effect on the B.A.S. score of being overweight in 1980

	Basic Skills Test Score 2004									
	MALES					FEMALES				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
	OLS	IV	MLE	Endog. Dummy Model	Endog. Switch. Model	OLS	IV	MLE	Endog. Dummy Model	Endog. Switch. Model
Overweight/Obesity in 1980	1.06	...	-7.39**	-3.11	-7.16	-0.75	- 12.11***	- 10.58***	-9.99***	-8.99
	(1.38)		(2.19)	(0.73)	St. Dev.: 3.40	(1.16)	(3.77)	(5.73)	(3.31)	St. Dev.: 3.29
Controls in X_{1i}	X	X	X	X	X	X	X	X	X	X
Controls in X_{2i}	X	X	X	X	X	X	X	X	X	X
Sargan Overid. Test p-value		0.115					0.040			
Endogeneity Test p-value		0.612					0.000			
Underid. Test p-value		0.000					0.000			
F-Test.		15.73					81.12			
λ				2.41					5.40***	
				(1.02)					(3.18)	
R^2 first stage										
cons	44.45***		33.17***	33.29***		41.04***	42.68***	42.15***	41.99***	
	(12.14)		(5.95)	(6.16)		(12.50)	(6.50)	(6.16)	(6.40)	
N	1704	1704	1704	1704	4350	1971	1971	1971	1971	4346

t statistics in parentheses;
* p < 0.10, ** p < 0.05, *** p < 0.001