

From the Department of Public Health Sciences
Karolinska Institute, Stockholm, Sweden

SOCIOECONOMIC CONSEQUENCES OF OBESITY

Population-based longitudinal studies of
Swedish men

Nina Karnehed



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To my beloved grandmother Birgit and grandfather Sven

ABSTRACT

The overall aim of the thesis was to study if Swedish obese male adolescents become socioeconomically disadvantaged in later life. Among Swedish men born 1951-79, who went through military conscription examination at age 18-20 years, the associations between obesity and attained education, occupation, income, and disability pension have been studied.

The target populations were identified in the Multi-Generation Register. A record linkage was made between this register and data from the following national registers: the Register of the Total Population, the Swedish Military Service Conscription Register, the Population and Housing Censuses, the Longitudinal Database of Education, Income and Occupation, Statistics Sweden's Register on School Marks, the Cause of Death Register, the Hospital Discharge Register, the Swedish Twin Register, and the Swedish Young Male Twin Study.

The associations between body mass index in late adolescence and later socioeconomic outcomes were analyzed by logistic regression, polytomous logistic regression, and Cox regression among all study subjects and by linear regression estimated with generalized estimating equations and conditional logistic regression within brother pairs.

The results showed that obese Swedish men are doing worse in the educational system than their normal weight counterparts even after adjustments for intelligence, parental education and parental socioeconomic position. Compared to normal weight counterparts, obese men were 40% less likely to start a university education (hazard ratio 0.63 95% confidence interval 0.60; 0.66) and 50% less likely to actually graduate (hazard ratio 0.48 95% confidence interval 0.44; 0.52). Second, obese Swedish men had an increased risk of approximately 35% of receiving disability pension (hazard ratio 1.35 95% confidence interval 1.19; 1.52) compared to their normal weight counterparts when own and parental socioeconomic factors were taken into account. Third, obese men were more likely to move downward and less likely to move upward in the social hierarchy compared to normal weight men. In addition, results showed that obesity was longitudinally associated to low educational level, low socioeconomic position and low income, irrespective of own intelligence, environmental and genetic factors shared by brothers, and parental socioeconomic position.

In conclusion, the results show that obesity in late adolescence has socioeconomic consequences in later life. Explanations for these consequences may be sought in the non-shared environment and are speculated to be co-morbidities of obesity, personal characteristics of obese individuals such as aspirations and self-esteem, or factors on the societal level such as discrimination.

LIST OF PUBLICATIONS

Karnehed N, Rasmussen F, Hemmingsson T, Tynelius P. Obesity and attained education: cohort study of more than 700,000 Swedish men. *Obesity (Silver Spring)* 2006; 14(8):1421-1428.

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LIST OF ABBREVIATIONS

BMI	Body Mass Index
CI	Confidence Interval
DZ twins	Dizygotic Twins
HR	Hazard Ratio
LOUISE	Longitudinal Database of Education, Income and Occupation
MZ twins	Monozygotic Twins
OR	Odds Ratio
WHO	World Health Organization

1 BACKGROUND

The prevalence of obesity has increased dramatically all over the world and also in Sweden the last decades (1). In Sweden, the number of overweight young men has doubled and the number of obese young men quadrupled the last 20 years (1;2). In the footsteps of the obesity epidemic co-morbidities such as diabetes and cardiovascular diseases prevail (3). However, obesity may not only be associated with medical consequences but also with socioeconomic consequences. In 2001, a thorough review of discrimination and obesity was published that stated that discrimination occurs in schools, health services and employment settings (4). It is problematic that a disease which is becoming more and more prevalent may affect not only morbidity and mortality but also social circumstances. Research on socioeconomic consequences of obesity in Sweden is scarce. If obesity leads to socioeconomic disadvantages in Sweden, socioeconomic positions of obese individuals will be lower than expected given their hypothetical potential. In this thesis I will use longitudinal studies of Swedish men to discuss socioeconomy, obesity, their relation, and the implications for the society.

1.1 SOCIOECONOMY

The main outcomes in this thesis (education, occupation, income and disability pension) are all related to socioeconomic position. The term socioeconomic position refers to a hierarchical position in a society. Social position is an entirely societal phenomenon; positions exist in relation to each other and co-define each other. A higher socioeconomic position denotes more power in the society. Social position can be viewed in many ways. Historically, different theories on this subject have emerged. Karl Marx introduced a theory in which the individuals in society were divided in those who produced goods and those who owned and controlled the production of goods (5). Weber, on the other hand, believed that the unequal distribution of economical means was created by stratification by class, status and political power (5).

Socioeconomic position, measured in various ways, has been found to be associated with health in numerous publications, across time periods, all around the world (5-9). The importance of socioeconomic circumstances during upbringing is stressed by the fact that childhood socioeconomic position has been shown to be associated with later health independently of own later attained socioeconomic position (10-13). A report from the World Health Organization (WHO) stated that most differences in health across socioeconomic strata in European countries are avoidable and unfair based on human rights principles (6).

Different explanations to the social divide in health have been proposed. According to the theory of social causation, a low socioeconomic position infers a higher probability for morbidity and mortality (14;15). There may be a number of explanations to why individuals of lower socioeconomic positions more often suffer from various health problems and preterm death. Lifestyle, knowledge, and resources in the lower positions might differ from that in the higher positions as well as exposure to more dangerous housing and working environments. People that have low socioeconomic positions are more likely to engage in behaviours of risk and less likely to engage in behaviours that are health promoting (16). An entire field of research is engaged in describing how working conditions might explain the social divide in health (17). Physical conditions, exposure to hazardous agents, and

psychological conditions differs between occupations and have been shown to be of importance in explaining the social divide in health (17). On the other hand, a poor health may also determine later socioeconomic position i.e. health selection (18-20). Many studies have tried to disentangle the relative importance of social causation and health selection for the social divide in health (15;19-21). However, social causation and health selection are operating concurrently (22;23). Transition between classes (i.e. social mobility) depend on the overall socioeconomic development of the society and general mobility patterns in the population. Transition can occur during the life course, so called intra-generational social mobility, and between generations, so called inter-generational social mobility (18). There is an ongoing discussion to what extent social mobility may increase or decrease the social divide in health (19).

In this thesis the term socioeconomic position will be used to denote the stratification of individuals in the society. An individual with a lower socioeconomic position will by definition have worse life chances.

1.1.1 Measurements of socioeconomy

The stratification of individuals in the society can be estimated by different factors, neither of which will capture the whole concept of socioeconomic position. Data can be collected at the individual, household, neighbourhood, and national level. This thesis will use information collected on the individual level.

The first step on the socioeconomic ladder is the attainment of education. Educational attainment measures a capability of understanding and processing information, and is also a measure of knowledge. Pros with measures of education are that information is highly available, reliable, and often constant during adulthood. Education can be thought of in a hierarchical way where more years of education are better than fewer. In Sweden, information on educational level can be attained via Statistics Sweden's registers. Cons with measures of education are that different levels of education might have different meanings in different societies, at different ages or in different birth cohorts. Sweden has nine years of compulsory schooling. After compulsory schooling adolescents may continue in upper secondary school with a practically oriented program or a theoretically oriented program. Universities are free of charge and admissibility criteria have been mostly based on marks. The average level of attained education has increased since the 1970s in Sweden (2).

Individuals with a high socioeconomic position in society most often have an occupation with a high status. The measure of occupation indicates working environment, but also to some extent material resources. The measure of occupation cannot be used for the fraction of the society that is outside the labour force. Statistics Sweden has developed a socioeconomic classification system that classifies persons within and outside the labour force (24). The occupations have been divided into groups according to their theoretical need of education. The classification system also makes a distinction between employed and self-employed. People outside the labour force are categorized as students, housewives, old age pensioners, disability pensioners, long-term unemployed or military conscripts.

Income is a more complicated variable than education or occupation. Income persists of components such as wage, social benefits and wealth. Factors such as size of the household and residence may also affect the interpretation of the measure. Income may be volatile and can fluctuate considerable over a year and, most certainly,

between years. It might also be difficult to interpret associations since a small increase in income in the lower range might have profound effects but the same increase in the higher range is trifling. The level of income predicts the purchase power, and consequently access to healthier, and often more expensive, foods and recreation. The different components of income can be collected from the registers of Statistics Sweden.

Neither of these measures will cover the concept of socioeconomic position in full, but will together cover a big part of the concept. Other measures that can be hypothesized to contribute to explaining the concept of socioeconomic position are housing, neighbourhood characteristics, and material resources.

1.2 OBESITY

Obesity is characterized by an accumulation of excess fat to the extent that it affects health. Obesity is defined as a chronic disease in Sweden and internationally (25;26). Body mass index (BMI) is calculated as weight in kilograms divided by squared height in meters (kg/m^2).

The WHO has defined obesity as a BMI value of 30 or more, overweight as $25 \leq \text{BMI} < 30$, normal weight as $18.5 \leq \text{BMI} < 25$, and underweight as a BMI value below 18.5 (25). Throughout the thesis the commonly accepted definition of obesity as a chronic disease, and not a flaw of character or an affliction treatable by willpower alone, will be used.

1.2.1 Occurrence of obesity

The prevalence of obesity has increased in Sweden among both men and women (27). In Sweden, the number of overweight young men has doubled the last 20 years (1;2). A study of 18 year old Swedish men born 1951-87 showed that the prevalence of obese men had quintupled and morbid obese men had increased ten-fold 1969-2005 (28). Statistics Sweden estimates that 10% of adult Swedish men were obese in 2004-2005 (29). A recent review of the prevalence of obesity in Sweden concluded that although the prevalence is still low in an international perspective the development is alarming (30). According to the most recent numbers from the WHO, the prevalence of obesity among adult males is 14% in Finland, 9.8% in Denmark, 6.8% in Norway, 22.6% in the United Kingdom, and 31.1% in the United States of America (31). The prevalence of obesity is still low in the developing countries but with increasing development the prevalence of obesity is increasing as well. It is estimated that by year 2015 diseases in part caused by over-nutrition will replace under-nutrition as the leading cause of death in low-income countries (32).

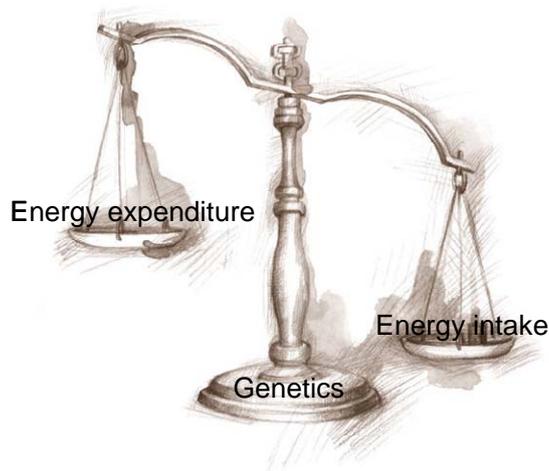
Not only are birth cohorts of today heavier than before at the same age, all birth cohorts are also becoming heavier with time. Obesity has a high rate of tracking over time so that obese adolescents become obese adults (33;34). In a Swedish cohort, very few obese young men became normal weight later in life (35). In conclusion, most obese adolescents become obese adults but not all obese adults have been obese in adolescence.

1.2.2 Aetiology of obesity

Imbalance in the equilibrium of energy intake and energy expenditure may result in accumulation of energy in the body (Figure 1). The causes of obesity are, however,

not fully disentangled. Twin, adoption, and family studies have shown that genetics play a significant role in the aetiology of obesity (36-40). When overfeeding identical twins the within-pair differences in weight gain were smaller than the differences in weight gain between the identical pairs indicating that genetic factors are involved in the regulation of the energy balance (37). Similarly, the response among identical twins to exercise during constant energy intake were more similar within the pairs than between the pairs (38).

Figure 1. The aetiology of obesity.



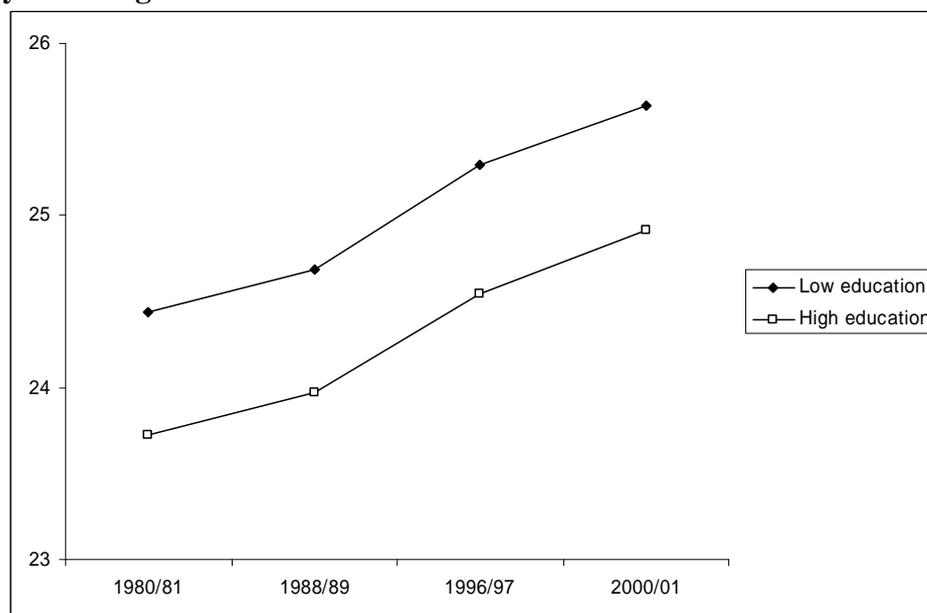
Energy surplus develops when energy intake exceeds expenditure. The balance is also affected by the genetics of energy intake and expenditure.

Heritability estimates have ranged from 5-90% depending on study population, age, period of time, and statistical methods (41). Four levels of genetic determination have been suggested: genetic obesity, strong genetic predisposition, slight genetic predisposition, and genetically resistant (41). Genetic obesity might for example be mutations in the genes of the pathways regulating hunger and satiety (41). Single gene mutations are, however, extremely rare. Those with strong genetic predisposition, e.g. the Pima Indians (42), are most likely to be obese in an obesogenic environment but healthy in an environment with restricted access to food and plenty of physical activity. The slight genetic predisposition plays a crucial role in public health since it is widespread in the population. Whether slight genetically predisposed will develop obesity depend on their lifestyle as well as social, behavioural, cultural, and community factors. Earlier research have shown that genetic predisposition to obesity affected how much weight were gained over time when exposed to an obesogenic environment (43).

Assortative mating, i.e. the choice of partner according to similarity of individual traits, has been reported with regard to BMI and may possibly contribute to the increasing prevalence of obesity (44). However, the increase in prevalence of obesity is not likely to depend on a change in the gene pool since these changes need considerable time to develop and spread in the population. The balance in the energy equilibrium is more likely to have been disturbed by changes in physical activity levels or dietary changes. The overall physical inactivity is increasing as a result of increasing hours of television viewing and decreasing hours of physical activity (45). Experimental studies on overfeeding have shown weight gain in response to excess calories (37;46).

Other risk factors for obesity are for example socioeconomic position, educational level, place of residence, age and sex (2;26;27;47-49). Figure 2 shows how a low educational level is associated with a higher BMI and how the mean BMI has increased over time in Sweden. Strong inverse associations have been reported between social position and obesity in many affluent societies (50;51). High-educated subjects have a lower risk of developing obesity than their low-educated counterparts (52). The reasons for socioeconomic position to have an impact on the prevalence of obesity may be that the knowledge of the importance of healthy eating habits and physical activity is better, the access to facilities promoting physical activity or good eating habits are better, peer pressure in the higher socioeconomic strata, and other life style factors.

Figure 2. Mean BMI among high educated and low educated Swedish men 18-84 years of age.



Age standardized mean values from the living conditions survey adapted from Kark et al (53).

1.2.3 Measurements of obesity

There are many different ways of measuring obesity. The use of BMI as a measurement of defining obesity has been proposed by the WHO (25). This classification system is based on epidemiological data indicating that preterm mortality starts at a BMI above 25 and then increases further at a BMI above 30. However, factors such as distribution of fat tissue on the body, fitness and ethnic background influence the relationship between BMI and mortality. Several South East Asian populations, for example, have a higher risk of morbidity and mortality than the Caucasian population at the same BMI (54). The BMI does not distinguish between weight emanating from body fat, muscle or skeletal compartments. Persons who have a large muscle mass may be classified as obese even though they have a normal amount of body fat. However, BMI correlates strongly with percentage of body fat on the group level and does not involve invasive or time consuming elements, thus, BMI is a useful and inexpensive measure of body fatness in large epidemiological studies (25;55).

Other measures often used in epidemiological research are measures of the waist circumference and the waist to hip ratio. When elevated, these measures indicate abdominal fat distribution and are independent risk factors for coronary heart disease among both lean and obese individuals (56;57). Skin fold measurement is another non invasive measure of body fat. This measure, however, demands skilled personnel to perform the measurements (58). Bioelectric impedance is a rather quick and inexpensive method for measuring body composition and is comparable to the BMI method with regard to validity (59). Dual-energy-X-ray absorptiometry measures body composition accurately although some validity issues regarding type of software and hardware have been raised (60;61). Dual-energy-X-ray absorptiometry is both time consuming and resource demanding and is not suitable for large scale epidemiological studies.

1.3 CONSEQUENCES OF OBESITY

1.3.1 Medical consequences of obesity

Obese individuals have an increased risk of premature death (62;63). At the age of 40, obesity decreases life expectancy with seven years (64). In a WHO review the most common medical complications of obesity were non insulin dependent diabetes mellitus, cardiovascular diseases, hypertension, gallbladder disease, and cancer (25). A recent review reported that approximately 90% of all individuals with non insulin dependant diabetes mellitus have a BMI higher than 23 and that up to two-thirds of all cases of hypertension are linked to excess weight (65). Additionally, approximately 10% of all cancer deaths among non-smokers could be attributed to obesity (65).

Many research publications have shown quality of life to be affected among treatment seeking obese individuals (66). In a small study severely obese patients reported that they would prefer being normal weight with a major handicap (deaf, blind, or one leg amputated) rather than being obese (67). Results from the Swedish Obese Subjects (SOS) study showed health-related quality of life to be improved after weight loss (68) and that this improvement in quality of life was sustained long term (69). However, obese patients seeking treatment may differ quite substantially from the obese in the general population with those seeking treatment probably having a more impaired quality of life (66). Body-esteem has been shown to be lowered with increasing BMI in the general population, but global self-esteem measures are not correlated with BMI to the same extent (70). However, a meta analysis from 1999 showed lower self esteem among obese individuals (71). Obesity has been shown not to be associated with mental domains of health in the general population (72).

1.3.2 Socioeconomic consequences of obesity

In this thesis socioeconomic consequences of obesity are defined as the attainment of a lower education, socioeconomic position or income than would have been attained if the condition had not been present. The attainment of disability pension can be regarded as a socioeconomic consequence of obesity as well as a medical consequence of obesity.

Strong inverse associations have been reported between social position and obesity from many affluent societies (52;73-76). Obesity has been shown to be associated with lower educational attainment among men (77;78). A study from Denmark in the 1980s found that obese men did not attain as high social position as their normal

weight counterparts when intelligence, education and parental social position were taken into account (74). A Finnish cross-sectional study showed that obese women more often are subject to unemployment and had lower income levels than normal weight women (75). The same research group also found income disadvantage among Finnish obese women with higher socioeconomic positions (79). International research have also found some income disadvantage among men although effect sizes were of small magnitudes (80;81). However, several studies have failed to show significant associations between obesity and social characteristics among men (75;76;82-88) and research from Sweden have found socioeconomic consequences of obesity among women only (20).

Obesity has been shown to be associated with sickness absence in earlier research (89-93). In line with this research, obese individuals were found to have lower work ability in a Finnish cohort (94). In Sweden, Månsson and colleagues found the risk of disability pension to be increased with increasing BMI, decreasing self-rated health and decreasing socioeconomic status (95;96). A cross sectional study by Narbro and colleagues showed that Swedish obese women, who had sought medical treatment for their condition, became disability pensioners 2.4 times more often than normal weight women (97). Narbro and colleagues, have also shown that Swedish severely obese subjects treated with surgery decreased their risk for disability pension (98).

In summary, longitudinal studies of socioeconomic consequences of obesity among men are inconclusive and research from Sweden is scarce.

1.4 CONCEPTUAL FRAMEWORK AND STUDY DESIGN

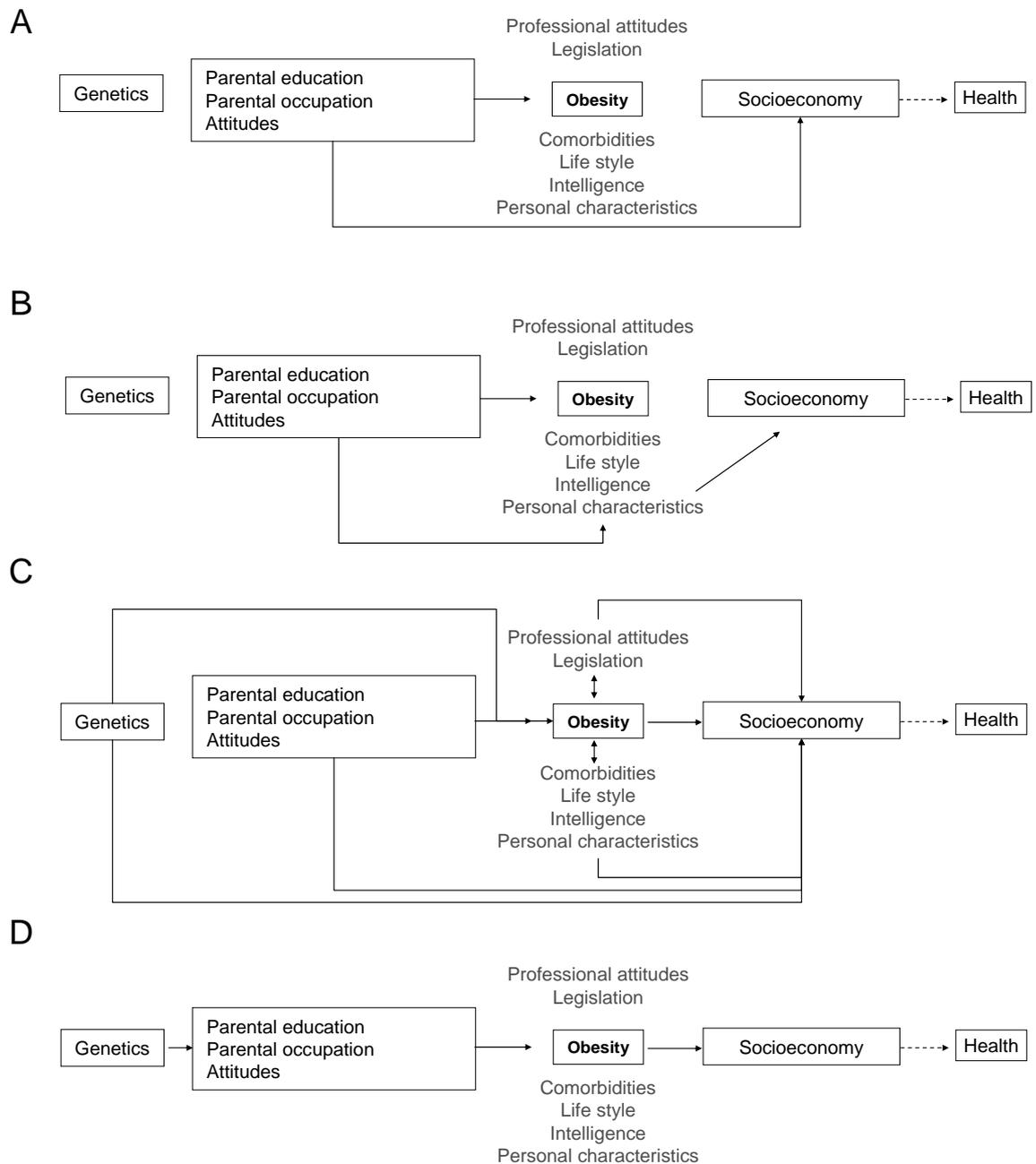
The study questions of this thesis are looked upon from a medical point of view with epidemiological methods. Epidemiological methods are used in many disciplines, for example medicine, sociology, and psychology but originate from the studies of infectious diseases within the discipline of medicine approximately 150 years ago (99). The concepts analyzed in this thesis and all included variables are on the individual level. Factors on other structural levels, such as national legislation or community characteristics, might affect the associations between obesity and socioeconomic characteristics, but these are not regarded in the analyses. Interaction between factors on different levels might also affect the associations; for example national legislation might affect different occupational groups differentially. However, even though the perspective of this work is on an individual level it will most certainly have societal implications.

The study questions of this thesis could have been investigated in different frameworks, for example within the sociological discipline and/or with qualitative methods. There are pros and cons with the different approaches. While a qualitative approach may increase the knowledge of the mechanisms behind the associations between BMI and socioeconomy such as individual experiences of body size and opportunities in life, the medical-epidemiological approach can generate estimates of the associations. It is important to emphasize that the risk estimates generated by epidemiological methods are not applicable on the individual level; e.g. it is not possible to predict the risk of social consequences for a specific obese individual compared to a normal weight individual per se, but the associations are valid when comparing groups of individuals.

The conceptual framework of this thesis is based on life course epidemiology (100). The life course epidemiology emphasizes that risk factors act during the life course. The application of this model demands a longitudinal setting with information from different periods in life. All studies included in the thesis are nationwide, population-based, and longitudinal, with information from large Swedish registers (more information in Material and Methods). With a life course approach, the relations between BMI and later socioeconomic outcomes are investigated. The life course model includes at least four broad models; the critical periods model, e.g. when a risk factor has impact during a specific window of time for example during foetal life, the critical periods with later effect modifiers model, the cumulative exposure model e.g. when the hazard of risk factors accumulate during life course, and the chain of risk model where one risk factor leads to another.

Based on the models of life course epidemiology Figure 3 illustrates how the association between obesity and socioeconomic characteristics might be understood. Panel A of Figure 3 illustrates the critical period model where a risk factor in childhood will increase the risk for both obesity and socioeconomic consequences. A hypothetical example is if low parental education infers worse food habits thus increasing the risk for obesity while at the same time inferring a risk for low attained education. Panel B of Figure 3 illustrates the critical periods with later effect modifiers model where a critical period risk factor will have effect only if some other factor is later present. A hypothetical example is, if parental education infers worse food habits thus increasing the risk for obesity, as in the previous example, but the risk for low attained education will only be present if the educational system is worse for those with lower compared to higher socioeconomic background. In the case of model A or B being true, associations between obesity and socioeconomic consequences would be entirely due to confounding from the early critical period risk factor. Panel C of Figure 3 represents the cumulative exposure model in which the hazards of risk factors accumulate during life course. In the case of this model all risk factors listed in model C would have an independent effect on the socioeconomic characteristics and risk factors would be accumulated among the obese. However, obesity might also have an effect on socioeconomic consequences independent of the accumulated risks. Panel D of Figure 3 illustrates the chain of risk model where risk factors leads to each other. In the case of this model breaking the chain at any point would prevent the socioeconomic consequence, thus, normal weight individuals with for example a lower socioeconomic background would not be at risk for a lower socioeconomic status as compared to those with higher socioeconomic background.

Figure 3. A life course approach to the relationship between obesity and socioeconomic characteristics.



Panel A represents the critical periods model where a risk factor during childhood causes the socioeconomic consequence.

Panel B represents the critical periods with later modifiers model where a risk factor during childhood causes the socioeconomic consequence only if a certain other risk factor is present.

Panel C represents the cumulative exposure model in which risk factors during life course all adds to the socioeconomic consequence.

Panel D represents the chain of risk model in which risk factors lead to other risk factors which in turn causes the socioeconomic consequence.

2 AIMS

The overall aim of the thesis was to study if, and how, Swedish males with obesity in late adolescence become socioeconomic disadvantaged in later life.

Specific aims were:

- 1.** To investigate the longitudinal relationship between obesity in late adolescence and later attained education.
- 2.** To investigate the longitudinal associations between obesity in late adolescence and later risk of disability pension.
- 3.** To investigate longitudinal associations between obesity in late adolescence and intergenerational social mobility.
- 4.** To investigate to what extent the hypothesized relationship between obesity in late adolescence and later socioeconomic disadvantage can be explained by common environmental factors and/or genetic factors.

3 MATERIAL AND METHODS

3.1 STUDY POPULATION

This thesis investigates associations among Swedish men born 1951-79 who went through military conscription examinations at age 18-20 years. The different studies deal with different sub-populations; the dataset was extended in 2007 thus the last study could include more birth cohorts. Study I deals with men born 1952-1973. Since study II investigates attained disability pension the study population was chosen to be of older age and includes men born 1952-1959. The same argument applies for study III that investigates attained occupation and includes men born 1951-1965. In study IV it was important to incorporate as many brother pairs as possible, thus, pairs born 1951-1979 were included. The study populations were followed from birth until 2001 (study I-III) and 2004 (study IV).

3.2 INFORMATION SOURCES

The target populations were identified in the Multi-Generation Register. A linkage was made between that register and the Register of the Total Population, the Swedish Military Service Conscription Register, the Population and Housing Censuses, the Longitudinal Database of Education, Income and Occupation (LOUISE), the Cause of Death Register, Statistics Sweden's Register on School Marks, the Hospital Discharge Register, the Swedish Twin Register, and the Young Male Twin Study.

3.2.1 Multi-Generation Register

The Multi-Generation Register includes all individuals who have been registered in the Register of the Total Population at some time since 1961 and that are born 1932 or later. Information includes biological and adoptive parents. Data quality for individuals born 1950 or later in Sweden is excellent with 99% of index individuals complete with mothers (101). However, the quality of information on parents for those born 1950 or later outside Sweden is worse with 27% of index individuals complete with mothers (101).

3.2.1.1 Variables used

Parents of study cohort members were identified in the Multi-Generation Register using the unique personal identification number ascribed to all individuals with permanent residence in Sweden. Each individual was assigned a family identification number and brothers having the same parents were assigned the same family identification number.

3.2.2 Register of the Total Population

The Register of the Total Population includes all individuals with permanent residence in Sweden. The register contains some extra individuals since all births and immigration are captured but emigration might in some cases be missed (102). Nevertheless, the overall quality of the register is regarded to be good (102;103).

3.2.2.1 Variables used

Data on migration was collected and country of birth was categorized as being born in Sweden or in a foreign country.

3.2.3 Swedish Military Service Conscription Register

During the study years military conscription was compulsory for all men with Swedish citizenship. The only reasons for exemptions were severe and disabling conditions that should be confirmed by a certificate issued by a physician. The Swedish military service conscription examinations involve medical and psychological assessments. For the great majority of young men conscription examinations took place at an approximate age of 18 years. The quality of the register can be regarded to be good. However, data on conscriptions from 1978, 1984, and 1985 have in part been lost. The losses have happened due to changes in the data management within the Swedish Military Service Conscription Register. This thesis includes information from the years 1969-1997.

3.2.3.1 Variables used

3.2.3.1.1 Conscription office

The conscription examinations took place in one of six different conscription offices (Boden, Göteborg, Karlstad, Kristianstad, Stockholm, or Östersund).

3.2.3.1.2 Body mass index

Height and weight were measured in light underwear under supervision by a nurse or a physician during military conscription examinations. BMI was calculated as weight (kilograms) divided by squared height (meters squared) and categorized as underweight ($BMI < 18.5$), normal weight ($18.5 \leq BMI < 25$), overweight ($25 \leq BMI < 30$), and obesity ($30 \leq BMI$) according to the WHO criteria (6).

3.2.3.1.3 Intelligence

The intelligence test used is included in the Swedish Enlistment Battery and matches the concept of general intellectual performance (104-107). There are four basic tests; a logic / general intelligence test; a verbal test of synonym detection; a test of visual-spatial / geometric perception; and a technical / mechanical skills test with mathematical / physics problems. A combined (global) intelligence score is derived from the conscripts' performance on all four tests and a Gaussian distributed score between 1 and 9 is generated.

3.2.3.1.4 Place of residence

Place of residence was recorded as type of municipality in 9 categories according to the classification of municipalities made by the Swedish Association of Local Authorities; main cities (>200,000 inhabitants), suburban municipalities (more than 50% of the nocturnal population work in another municipality), large cities (50 000-200 000 inhabitants), middle size cities (20 000-50 000 inhabitants), sparsely populated municipalities (less than 20 000 inhabitants and less than 5 inhabitants per sqkm), industrial municipalities (more than 40% of the inhabitants are working within the industrial sector), rural municipalities (more than 6.4% of the population are within the rural sector), other larger municipalities (15 000-50 000 inhabitants), and other smaller municipalities (<15,000 inhabitants).

3.2.4 Population and Housing Censuses

The Population and Housing Censuses were performed in 1960-1990 and were compulsory. The Population and Housing Censuses of 1990 had a non-participation

rate of 2.5% which was the highest reported (108). Quality can be regarded to be good (108).

3.2.4.1 Variables used

3.2.4.1.1 Socioeconomic index

Socioeconomic classification was based on occupational codes from Population and Housing Censuses 1960, 1970, 1980, 1985 or 1990. Occupations were classified in accordance with the Statistics Sweden's socioeconomic index classification into non-manual high, non-manual intermediate, non-manual low, skilled workers, unskilled workers, farmers and others (those for whom no specific occupation was reported).

Parental socioeconomic position was used as proxy for childhood socioeconomic position. Highest attained socioeconomic position of either parent (where non-manual high was considered the highest and the unclassified the lowest) was used since many mothers were within the labour force. Own socioeconomic position was measured at an approximate age of 30 years (own socioeconomic position from Population and Housing Censuses 1980, 1985 or 1990).

3.2.4.1.2 Social mobility

Intergenerational social mobility was measured as a comparison between paternal socioeconomic position in childhood and own socioeconomic position at an approximate age of 30. Only individuals within the labour force were included in the comparison. Farmers were excluded from the comparison since farmers are difficult to incorporate in the hierarchical system. Social mobility was classified as upward (higher socioeconomic position than father), downward (lower socioeconomic position than father) or same (same socioeconomic position as father).

3.2.5 LOUISE

The LOUISE includes all individuals registered in Sweden 31/12 the year in question and covers information on education, occupation, and income during the years 1990-2004 (109). The quality of LOUISE depends on the quality on the registers from which information is gathered, and can in general be regarded as good.

3.2.5.1 Variables used

3.2.5.1.1 Education

Educational attainment was classified as less than 9 years of primary school, 9 years of primary school, less than 2 years of secondary school, 2-3 years of secondary school, less than 3 years of higher education, 3 years of higher education or more, and PhD-education. A high education was defined as at least 15 years of education (corresponding to the minimal requirements for a university degree in Sweden) or defined as at least 13 years of education (corresponding to at least 1 year of university education). Time for highest attained education was collected 1990-2001 when available.

3.2.5.1.2 Disability pension

According to Swedish legislation during the study period (1990-2001) disability pension could be granted by the social insurance office if working ability is reduced with at least 25% due to disease. To be eligible for disability pension a certificate

issued by a physician must affirm the disability. However, during the study period, disability pension has been used to reimburse individuals with difficulties to enter the labour market and for individuals excluded from the work force for other reasons than a specific disease. A person was considered to be a disability pensioner if recorded as such in LOUISE two consecutive years. This conservative definition was applied to make sure to include only subjects who had been excluded from working life on a long-term basis. Information on disability pensions was available between the years 1990 to 2001.

3.2.5.1.3 Income

Annual income generated from employment, not including social benefits, was collected.

3.2.5.1.4 Marital Status

Marital status was collected and categorized as being married or not.

3.2.5.1.5 Place of residence

Place of residence was recorded as described earlier under the Swedish Military Service Conscription Register.

3.2.6 Cause of Death Register

All deaths and causes of deaths in Sweden are registered by The National Board of Health and Welfare. The quality on deaths occurring in Sweden is good although some deaths occurring among emigrated individuals might be missed (102).

3.2.6.1 Variables used

Data on date of deaths were used.

3.2.7 Statistics Sweden's Register on School Marks

The register includes information on schools, results from national tests, school marks from 9th grade, and school marks from 12th grade. The schools are responsible for reporting to Statistics Sweden according to Swedish law and the quality can be regarded to be good (29).

3.2.7.1 Variables used

Data on school marks from 9th grade and type of upper secondary school were collected for men born 1972-73.

3.2.8 Hospital Discharge Register

The Hospital Discharge Register is held by The National Board of Health and Welfare and covers dates of admissions and ICD-diagnoses from 1964 and onward. The register quality can be regarded to be good from 1987 and forward (110).

3.2.8.1 Variables used

Diagnoses from the Swedish Hospital Discharge Register were used as a crude proxy measure of morbidity in study II. Information on psychiatric hospital discharges and

hospital discharges due to injuries was collected. Information was collected 1987-1990 and coded as ever or never hospitalized.

3.2.9 Swedish Twin Register

The Swedish Twin Register contains, in principle, all twins born in Sweden since 1886 (111;112). Zygosity was determined by questionnaires based on validated questions and the questions proved to be correct in 99% of the pairs in a validating study within this particular cohort (113).

3.2.9.1 Variables used

Data on zygosity was used.

3.2.10 The Young Male Twin Study

The Swedish Young Male Twins Study was created in 1998 and includes twins born in Sweden 1973-79, who were Swedish residents in 1997 (114). Information about zygosity was collected by questionnaires based on validated questions (112;113;115). Twins belonging to complete pairs of undetermined zygosity were offered a DNA-test as described elsewhere (43;116).

3.2.10.1 Variables used

Data on zygosity was used.

3.3 STATISTICAL ANALYSES

The associations between BMI and later socioeconomic outcomes and their 95% confidence intervals (CI) were estimated with standard regression methods available in statistical packages such as SAS (SAS Institute Inc., Cary, NC, USA) and STATA (Stata Corporation, College Station, Texas, USA). Since the datasets in study I-III included families with multiple siblings, who are correlated and thus violates the usual independence assumption, standard errors were adjusted with a robust sandwich estimator (117).

3.3.1 Analyses of individuals

3.3.1.1 Logistic regression

Logistic regression models were used to predict the odds ratio (OR) of attaining a high education in paper I using PROC LOGISTIC in SAS (118).

3.3.1.2 Polytomous logistic regression

Polytomous logistic regression is an extension of the logistic regression model and is used when the categorical dependant variable has more than two levels. Polytomous logistic regression analyses were performed in STATA version 9.0 with the MLOGIT command to estimate the risk of being upwardly mobile, downwardly mobile, or stable in the social hierarchy in study III (119).

3.3.1.3 Cox regression

Cox proportional hazards regression using PROC PHREG in SAS was used to estimate the hazard ratios (HR) of attaining a high education and disability pension in study I and II respectively (118). The proportional hazards assumption was checked

graphically. Cox proportional hazards regression was used to estimate the chance of attaining a high education (study I) and the risk of becoming a disability pensioner (study II) for underweight, normal weight, overweight and obese men.

3.3.2 Analyses of brother pairs

In study IV the genetic and environmental contributions to the associations between obesity and socioeconomic characteristics were studied. This work was based on the assumptions that siblings are raised in a similar family environment and that ordinary brothers and dizygotic (DZ) twin pairs share, on average, 50% of their genes whereas monozygotic (MZ) twin pairs share all their genes. Twins share the time period in which they are raised and even share their foetal environments which make them even more prone to similarity than ordinary brothers. When raised together, sibling pairs share common environmental factors that normally are difficult to control for in statistical models such as maternal characteristics fixed from pregnancy to pregnancy and parental characteristics such as socioeconomic position, housing, neighbourhood characteristics, life style etc. In analyses within sibling pairs all factors shared by the pair (as mentioned above) are taken into account by the matching and confounding by these variables is accordingly accounted for.

3.3.2.1 Linear regression

Linear regression was used to assess the effect of BMI on income and education within and between pairs of ordinary full brother, MZ twins, and DZ twins in paper IV. Generalized estimating equations were used to account for the correlation between brothers (117). Analyses were performed in SAS with PROC GENMOD (118).

3.3.2.2 Conditional logistic regression

Conditional logistic regression was used to estimate the odds of being the brother with the high/highest socioeconomic characteristic per unit increase in within-pair difference in BMI or the risk of being the brother with the high/highest socioeconomic characteristic for underweight, normal weight, overweight and obese brothers in study IV. Analyses were performed in SAS using PROC LOGISTIC (118).

4 ETHICAL CONSIDERATIONS

The studies included in this thesis are approved by the Regional Ethics committee, Stockholm, Sweden. There are however ethical issues that may be discussed.

4.1 THE SCIENTIFIC AGENDA

Scientific ideas, beliefs and agendas are affected by dominant social beliefs. What questions that are put, and perceived interesting and important, depend on the time in which research are performed. This thesis investigates if body size denotes different life chances. If this approach can be regarded as ethical or not most certainly depend on social beliefs. The ethical key issue is that obesity is, nationally and internationally, defined as a chronic disease. Thus, obesity is not just a cosmetic problem or a body size differing from the social norm.

4.2 THE BENEFIT OF THIS THESIS

It is important to discuss who will benefit from the knowledge generated by the research. The conclusion of this thesis is that obese Swedish men have worse life chances than normal weight Swedish men. Depending on the reasons for these worse life chances the results may have different implications. If obese individuals cannot reach their full potential due to social obstacles the whole society would gain (human resources and financially) from removing these obstacles. Obese individuals might also, in addition to social obstacles, have worse life chances due to individual factors such as comorbidities or personal characteristics such as self-esteem and aspirations. If obesity correlates with lower ability or lower aspirations to gain a high education, higher socioeconomic position or a higher salary the results of this research might put strain upon the obese. In fact, any attention directed towards the association between obesity and socioeconomic characteristics might lead to distress among the obese. However, I believe that obese people will benefit from the knowledge generated by this thesis and that the entire society will gain in the short and long term from addressing these issues.

4.3 THE GENDER ISSUE

This thesis is based on data from men only. International and Nordic research have shown socioeconomic consequences of obesity to be more profound for women than for men (75;76;79). It would, however, be impossible to do a similar study on women in Sweden since military enlistment examinations are compulsory for men only and similar BMI data from such a large sample of women are not available. Nevertheless, the majority of studies in medicine are performed on males and this issue should be discussed in every single study that chooses to exclude women.

5 RESULTS

5.1 STUDY POPULATION

All non-adopted men born 1951-1979 and ever resident in Sweden with at least one biological parent in the Multi-Generation Register, who could be identified in the Multi-Generation Register of 2004 (N=1 691 262) were included in the study population. Out of these men 92% (N=1 561 536) were alive and Swedish residents at the time of conscription due to migration and death before age 20. The Swedish Military Service Conscription Register contained 89% of these men (N=1 394 116). The reason for this number not being higher is that the Swedish Military Service Conscription Register has lost data on men born 1960 (data from conscription available for 18% of the men), 1966 (data from conscription available for 64% of the men) and 1967 (data from conscription available for 40% of the men). Data can also only be found for 23% of the men born 1979 since a new version of the Military Service Conscription Register, which is not used in this thesis, was launched in 1997. When exempting those born 1960, 1966, 1967, and 1979 mean conscription frequency was 97%. Figure 4 shows the number of men that are not included in the thesis due to migration or death as well as an approximate number of men being lost from the MSCR due to administrative problems.

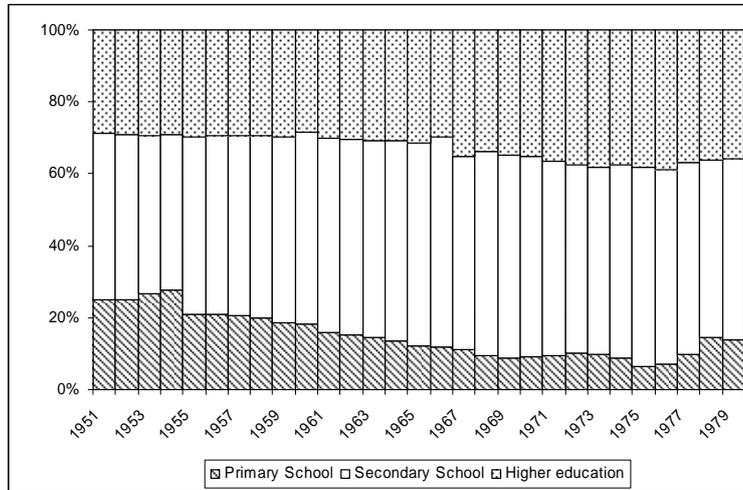
Figure 4. Study population.

Born 1951-1979 and ever resident in Sweden:	N=1 691 262
Conscripted men:	N=1 394 116
Migration:	N= 106 550
Death before age 20 years:	N= 23 854
Data lost from the MSCR assuming a conscription frequency of 97% among men born 1960, 1966, and 1967:	N= 91 691
Data in the new MSCR assuming a conscription frequency of 97% among men born 1979:	N= 34 159
Theoretical number of conscripted men: 1 394 116 + 91 691 + 34 159	
Theoretical number of Swedish citizens at the time for conscription: 1 691 262 – 106 550 – 23 854	
Theoretical conscription frequency:	$\frac{1394116+91691+34159}{1691262-106550-23854} \approx 0.97 = 97\%$

As can be seen in panel A of figure 5 the educational level has increased over time with a larger proportion of the younger cohorts having attained a higher education. The prevalence of overweight and obesity has increased in the study population over time, as shown in panel B of figure 5. When stratifying the proportion of obese men by socioeconomic position or educational level (panel C of figure 5) a clear cut pattern can be seen with educational level and socioeconomic positions being inversely associated with the prevalence of obesity.

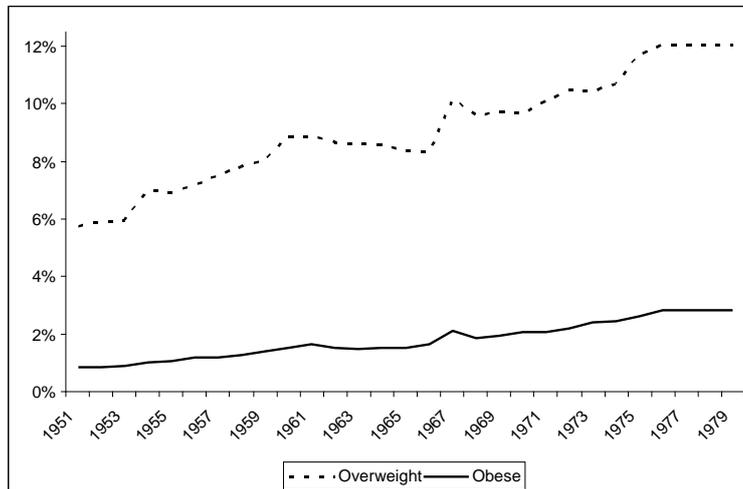
Figure 5. Crude distributions of characteristics among 1.4 million Swedish men born 1951-1979 who had completed their conscription examinations.

A



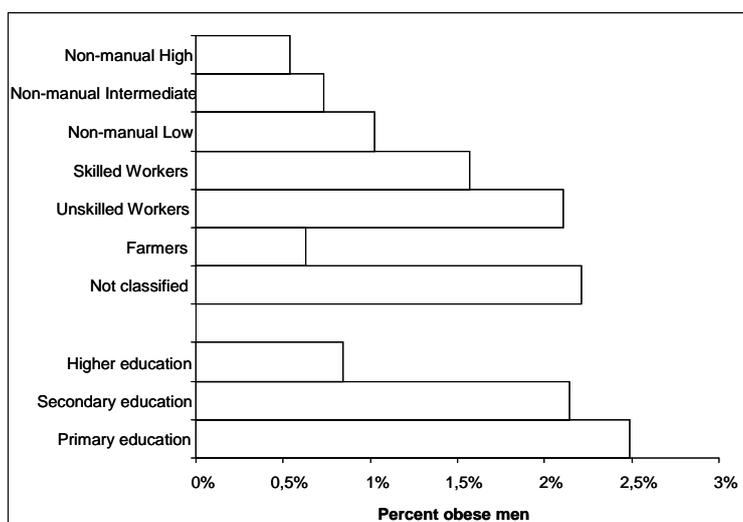
Panel A shows the educational distribution, measured in 2004, in percent.

B



Panel B shows the percentage of obese and overweight men.

C



Panel C shows the proportion of obesity at age 18 according to socioeconomic position, measured 1990, and educational level, measured 2004.

5.2 MAIN RESULTS OF STUDY I

Analyses included 752 283 men born 1952-1973. The mean age of attaining a high education was 27.3 years (range 20.0 to 48.8 years). When normal weight individuals were set as reference in the univariate Cox regression model, underweight, overweight, and obese men had a decreased likelihood of attaining high education (Table 1). Analyses were stratified by birth year but no significant change in the relation between BMI and attained education was observed over time (data not shown).

The multivariate models included adjustments for performance on the intelligence test, height, parental education and occupation, country of birth, municipality, and conscription centre (Table 1). In the fully adjusted Cox regression model, the association between BMI and attainment of high education became weaker but remained highly significant (HR for obese subjects 0.48 95% CI 0.44; 0.52). The associations between BMI and attained education were somewhat weaker when the outcome was redefined as at least 13 years of education, corresponding to at least 1 year of university studies (HR for obese subjects 0.63 95% CI 0.60; 0.66). Accordingly, obese men had a HR of 0.63 of starting a university education and a HR of 0.48 to graduate compared to normal weight men.

A subpopulation of 93 374 men born 1972-73 with register information on school marks from 9th grade (age 15 years) were identified. When adjusting the Cox regression models for 9th grade school marks the HR for high educational attainment could not be further explained by inclusion of type of secondary school program (year 10-12), intelligence test performance, height, municipality, or conscription centre (Table 1).

Figure 6 shows the associations between categories of BMI and prevalence of high education (left panel) or adjusted HR for high education (right panel) stratified by intelligence test score. The statistical interaction between intelligence and obesity was significant ($P=0.0055$). The higher the intelligence was the larger the consequences of being obese were.

Table 1. Hazard ratios of attaining a high education and their 95% confidence intervals.

	Model 1 N=752 283	Model 2 N=752 283	Model 3 N=93 282	Model 4 N=93 282
Underweight	0.93 (0.91; 0.95)	0.94 (0.92; 0.95)	1.07 (1.01; 1.13)	1.03 (0.97; 1.09)
Normal weight	1.00	1.00	1.00	1.00
Overweight	0.54 (0.53; 0.56)	0.70 (0.68; 0.72)	0.75 (0.71; 0.80)	0.76 (0.72; 0.81)
Obese	0.30 (0.28; 0.32)	0.48 (0.44; 0.52)	0.56 (0.47; 0.68)	0.57 (0.48; 0.68)

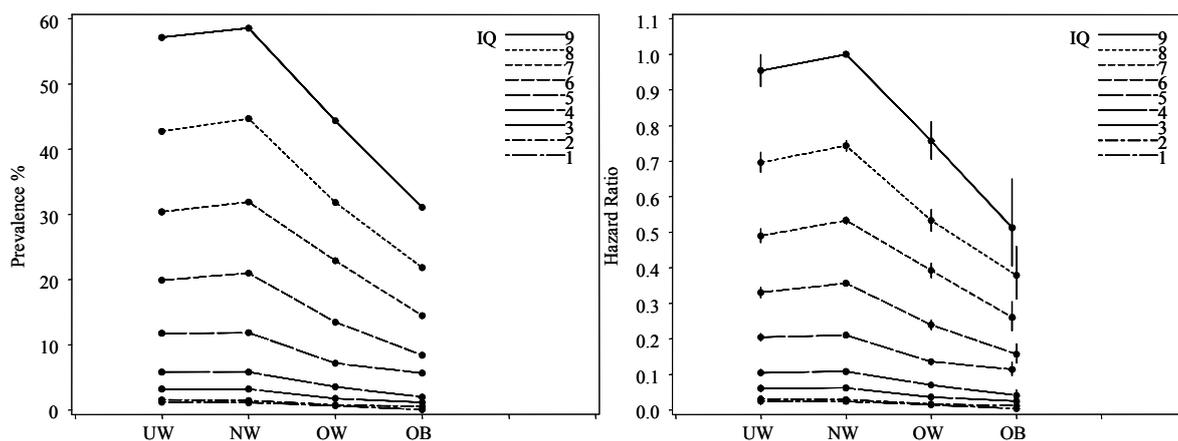
Model 1 is a crude Cox proportional hazards model.

Model 2 is adjusted for parental education, parental occupation, intelligence test performance, height, country of birth, municipality, and conscription office.

Model 3 is adjusted for parental education, parental occupation, country of birth, and 9th grade mean school marks.

Model 4 is adjusted for parental education, parental occupation, country of birth, and 9th grade mean school marks, type of secondary school program (year 10-12), intelligence test performance, municipality, conscription office.

Figure 6. Associations between categories of BMI and high education stratified by intelligence test performance among 752 283 Swedish men.



Left panel showing the unadjusted prevalence of high education and right panel showing the corresponding hazard ratios (adjusted for parental, education, parental occupation, intelligence test performance, height, country of birth, municipality, and conscription office) with 95% confidence intervals.

UW Underweight

NW Normal weight

OW Overweight

OB Obese

IQ Intelligence test performance

5.3 MAIN RESULTS OF STUDY II

The analyses included 366 929 men born 1952-1959. In total 3.8% received a disability pension during follow up. The proportion of men receiving a disability pension was 4.7% among the underweight, 3.6% among the normal weight, 4.2% among the overweight and 6.6% among the obese men during the follow-up from 1990 to 2001.

When using normal weight individuals as reference group in the univariate Cox regression model, underweight, overweight, and obese men had an increased risk of receiving disability pension (Table 2). The multivariate analyses were adjusted for country of birth, municipality, conscription centre, parental education, parental occupation, marital status, education, occupation, and presence of hospital discharge diagnosis 1987-1990. Underweight men had a slightly increased risk compared to normal weight men whereas obese men had an increased risk for disability pension of 35% (Table 2).

Table 2. Hazard ratios and their 95% confidence intervals of receiving a disability pension among 366 929 Swedish men.

	Model 1	Model 2	Model 3	Model 4	Model 5
Underweight	1.31 (1.25; 1.37)	1.30 (1.23; 1.36)	1.16 (1.11; 1.22)	1.14 (1.09; 1.20)	1.14 (1.09; 1.20)
Normal weight	1.00	1.00	1.00	1.00	1.00
Overweight	1.18 (1.11; 1.26)	1.19 (1.12; 1.27)	1.03 (0.96; 1.09)	1.03 (0.96; 1.09)	1.03 (0.96; 1.09)
Obese	1.90 (1.68; 2.14)	1.92 (1.70; 2.16)	1.40 (1.24; 1.58)	1.36 (1.20; 1.53)	1.35 (1.19; 1.52)

Model 1 is a univariate Cox regression model.

Model 2 is adjusted for country of birth, municipality and conscription centre.

Model 3 includes adjustments as in model B and is additionally adjusted for parental education, and parental occupation.

Model 4 includes adjustments as in model C and is additionally adjusted for own marital status, education, and occupation.

Model 5 includes adjustments as in model D and is additionally adjusted for inpatient hospital discharge diagnosis 1987-1990.

5.4 MAIN RESULTS OF STUDY III

The target population consisted of 752 081 men born 1951-1965 who were Swedish citizens and alive at the time of conscription. The descriptive analyses of social mobility included 639 486 men (85%). Social mobility could be seen from all socioeconomic positions groups of origin. Overweight and obesity were more common in groups emanating from a lower childhood socioeconomic position. This pattern was evident in all adult socioeconomic positions. Overweight and obesity were also more common in lower adult socioeconomic positions. The lowest mean BMI and the lowest proportion of overweight and obese individuals were seen among those who belonged to the socioeconomic position of high non-manual employees in childhood and adulthood. These results were unadjusted and might be confounded by other factors, for example intelligence.

The polytomous logistic regression analyses of intergenerational social mobility included 489 611 men (65%) and compared the risk of moving up, down, or being stable in the social hierarchy among underweight, normal weight, overweight and obese men. In the fully adjusted analyses of social mobility (Table 3) compared to being stable, obese and overweight men had an statistically significant increased risk of downward social mobility and a decreased risk of upward social mobility compared to normal weight men.

Table 3. Odds ratios for being upwardly or downwardly mobile compared to being stable among underweight, overweight and obese men compared to normal weight men.

	Same as father OR	Upward OR (95%CI)	Downward OR (95%CI)
Underweight	1.00	0.97 (0.95; 1.00)	1.06 (1.03; 1.08)
Normal weight	1.00	1.00	1.00
Overweight	1.00	0.86 (0.84; 0.88)	1.13 (1.09; 1.17)
Obese	1.00	0.72 (0.67; 0.77)	1.32 (1.22; 1.43)

Odds ratios (OR) and their 95% confidence intervals (CI) were estimated among 489 611 Swedish men born 1951-65 and were adjusted for childhood socioeconomic position, 5-year birth cohort, intelligence at age 18, attained education, conscription office, and municipality.

5.5 MAIN RESULTS OF STUDY IV

The target population included complete full brother pairs born 1951-1979 who were Swedish citizens at the age of 18 years (N=709 816). An association between obesity and socioeconomic outcomes could be observed within brother pairs. The obese brothers had approximately 20% lower chances of having the highest socioeconomic position at age 30 years (OR=0.78 95% CI 0.70; 0.87) or the highest income in 2004 (OR=0.79 95% CI 0.71; 0.87) compared to their non-obese brothers. When being the obese brother, the ORs of also being the brother with a high education (≥ 3 years of higher education) was lower (OR=0.60 95% CI 0.51; 0.72) than the ORs of also being the brother with the highest education over the whole range (OR=0.83 95% CI 0.77; 0.89).

The ORs of different socioeconomic outcomes were calculated per unit increase in BMI (Table 4). Ordinary brothers, MZ twins, and DZ twins showed quite similar patterns suggesting that associations between BMI and socioeconomic outcomes persist within twin pairs (with minor exceptions among the non-significant results).

Table 4. Odds ratios (ORs) for having the high/highest socio-economic position per unit increase in BMI at age 18.

	Ordinary brothers	MZ brothers	DZ brothers
OR of being the brother with a high education	0.94 (0.93; 0.95) N=56 595	0.92 (0.70; 1.22) N=270	0.97 (0.81; 1.16) N=361
OR of being the brother with the highest education	0.97 (0.96; 0.98) N=173 076	0.95 (0.81; 1.13) N=692	0.96 (0.87; 1.06) N=1097
OR of being the brother with the highest socioeconomic position	0.97 (0.96; 0.97) N=82 430	1.01 (0.82; 1.26) N=407	1.0 (0.90; 1.12) N=635
OR of being the brother with the highest income	0.99 (0.98; 0.99) N=107 996	1.12 (0.94; 1.32) N=708	0.97 (0.87; 1.09) N=891

BMI used as a continuous variable within the range 20.5- 40 kg/m².

Income range 100 000-1 000 000 SEK.

Adjusted for birth year and intelligence test performance.

N= Number of individuals included in the analyses.

The within- and between-pair effect in income and education was estimated by linear regression using generalized estimating equations. The within-pair effect is matched for shared family environmental factors and 50% genetics among ordinary brother pairs and DZ twins and 100% genetics among MZ twins. The between-pair effects lack this matching and can consequently be affected by genetic as well as environmental factors.

Among all brother pairs the unadjusted effect of one unit increase in BMI on income was larger between pairs than within pairs. Adjusting the models for IQ, childhood socioeconomic position, and adult socioeconomic position attenuated the effects but the between pairs effect was still larger than the within pair effect. Among ordinary brother pairs both the unadjusted and adjusted models produced a significant larger between-pair effect than within-pair effect (P for difference <0.0001 and P=0.0237 respectively). It was only the differences between pairs in income that were significantly different from null for the twins. Among ordinary brother pairs the unadjusted effect of one unit increase of BMI on educational attainment was larger between pairs than within pairs (P for difference <0.0001). Adjusting the models for intelligence test performance, childhood socioeconomic position, and parental education attenuated the difference but the between-pair effect was still larger than the within-pair effect and the P value for the difference was highly significant (P <0.0001). In the fully adjusted models estimated effects were similar across ordinary brothers, MZ twins and DZ twins although twin effects were not statistically different from null.

Since the between-pair effects were larger than the within-pair effects, genetics and common family environment can be assumed to confound the associations between BMI and income/education. However, the associations between BMI and income/education were detectable also within MZ twin pairs thus the explanations behind these association should not only be genetics or common family environment.

6 DISCUSSION

6.1 MAIN FINDINGS

Obese Swedish men have worse life chances than normal weight men. First, obese men in Sweden are doing worse in the educational system than their normal weight counterparts even though adjustments were made for intelligence, parental education and parental occupation. Compared to normal weight counterparts, obese men were 40% less likely to start a university education and 50% less likely to actually graduate. Analyses also indicate that obese pupils may have received lower school marks than would be expected based on their intelligence test performance. Second, obese Swedish men had an increased risk of approximately 35% of receiving disability pension compared to their normal weight counterparts when own and parental socioeconomic factors were taken into account. Both the risk of low educational attainment and the risk of disability pension are associated with BMI in a J-shaped fashion thus indicating a dose-response relationship. Third, results showed that obese men more often are downwardly mobile in the social hierarchy and less often upwardly mobile compared to normal weight men. The results also showed that although genetics and environmental factors shared by brothers had important influences on the longitudinal relationship between obesity and socioeconomic outcomes they could not fully explain the association. Obesity was longitudinally associated with low educational level, low socioeconomic position and low income when own intelligence, common environmental factors, genetics and parental socioeconomic position were taken into account.

6.2 MAIN FINDINGS IN RELATION TO EARLIER RESEARCH

The first step on the socioeconomic ladder is attainment of education. Good school performance has been shown to be inversely associated with being obese in boys and girls in both developed and developing countries in cross sectional studies (120-122). However, to disentangle causality, longitudinal studies are needed and only a handful of such studies have found obesity to be associated with educational attainment among men (74;77;78).

The second step on the socioeconomic ladder is attainment of an occupation, and with this occupation, a socioeconomic position. Several studies have failed to show significant associations between obesity and different social characteristics among men (75;76;82-88). Blane et al did not find BMI to be related to attained socioeconomic position in a Scottish cohort, however, BMI was measured in middle age and only individuals still belonging to the labour force in middle age were included (86). A longitudinal study from northern Finland found no association between obesity at age 14 and later history of unemployment among men (87). McLean and Moon found no income disadvantage among obese men (88). Our results are, however, in accordance with Sonne-Holm et al who in a study from the 1980s of Danish male conscripts found that obese men did not attain as high social positions as their normal weight counterparts when intelligence, education and parental social position were taken into account (74). Averett and Korenman found some income disadvantage among men, and in accordance with the results of this thesis effects were of small magnitudes (80). The results of Baum and Ford on income are also in accordance with results of this thesis, they could, however, not find any effect within sibling pairs contrary to my results (81). In addition, studies have shown obese subjects to be less attractive as future employees (123;124).

There are a number of possible explanations to the discrepancies with existing literature. First, the prevalence of obesity was 1.8% in the study population, which is rather low in an international perspective. However, our results showed that the associations between BMI and socioeconomic characteristics were similar among the oldest and the youngest of the investigated birth cohorts even though the prevalence of obesity had increased over time. Second, the social climate in Sweden may be particularly harsh against those departing from the predominant norms. Crandall argued that obesity might be especially stigmatized in cultures that value Protestant work ethic and appreciate self-control and self-discipline (125). Attitudes towards obesity in Sweden have not been studied and it is only possible to speculate on how they might depart from those in other western countries. Third, the large studies included in this thesis with higher statistical power compared to earlier studies, objective measurements of exposure and outcome variables, and the temporal order of measurements may have revealed associations not uncovered in earlier studies.

Study II showed the risk of attaining a disability pension to be increased when being obese in late adolescence compared to being normal weight. Our findings are in line with a previous study, conducted on a young employed population, which showed that obese individuals had poor work ability more often than their normal weight counterparts (94) and with previous research from Sweden (95-97).

In studies I-III parental education, childhood socioeconomic position, own intelligence and type of municipality could be ruled out as only explanations for the socioeconomic differences between obese and normal weight men. Silventoinen et al suggested that common genetic factors affecting both BMI and education are likely explanations for the correlation between these two variables (126). However, results of study IV suggested that neither genetic factors nor environmental factors shared by siblings within the family could explain the longitudinal relationship between obesity and socioeconomic outcomes. It should, however, be kept in mind that ordinary brothers share 50% of their genes, therefore genetic explanations to the relationships between BMI and socioeconomic outcomes cannot be ruled out completely. Nevertheless, results suggested that, although statistically non-significant, an effect of BMI on socioeconomic characteristics persisted even within MZ twins (who share 100% of their genes).

6.3 OBESITY AND SOCIOECONOMY IN A LIFE COURSE PERSPECTIVE

The aim of the thesis has been to resolve if obesity is associated with later socioeconomic. In the section of conceptual framework and study design several life course models were presented in Figure 3.

The model that seems to fit the data of this thesis the best is the cumulative exposure model since all measured variables included in the statistical models of study I-IV were independently associated with socioeconomic characteristics later in life. Those men that had none of the risk factors were the most fortunate and those who had all of the risk factors were the least fortunate. Risk factors for lower socioeconomic position were shown to accumulate among the obese during the life course since adjustments for parental education, parental occupation, and attained intelligence attenuated the association between obesity and socioeconomic characteristics. However, the accumulated risk factors among the obese could only explain a part of

the association between obesity and socioeconomy in and obesity was shown to be independently associated with socioeconomy.

6.4 METHODOLOGICAL CONSIDERATIONS

The studies in this thesis have several strengths. The studies are large, nationwide and population-based. Important strengths are the objective measures of height, weight, childhood socioeconomic position, parental education and attained education. An additional important strength is the longitudinal design with access to data from several periods during the life course.

6.4.1 Reversed causation

As mentioned in the introduction low socioeconomic position is a risk factor for the development of obesity. Reversed causation is prevented by first collecting information regarding childhood socioeconomic circumstances, then information on height and weight, and after that information on attained socioeconomic characteristics. The association of the thesis that is most sensitive to reversed causation is the association between obesity and attained education since the highest attained education in some cases might have been attained in late adolescence. However, although reversed causation might have contributed to the association between obesity and attained education it should not contribute to the association between obesity and attainment of occupation, income or disability pension. Since all associations between obesity and socioeconomic characteristics point in the same direction, reversed causality should be of minor importance.

6.4.2 Precision

The precision in a study is influenced by the amount of random error and can be estimated by looking at the width of the confidence interval around the point estimate (127). The precision is primarily affected by the study size. The precision of the estimates of regression coefficients in studies I-III was high in most analyses as indicated by tight confidence intervals. The precision, and consequently also the power, of several of the analyses in study IV was lower, especially for the twin estimates.

6.4.3 Validity

The validity of a study is often expressed in terms of absence of bias, also called systematic error (127). Bias in epidemiological research can be divided into selection bias, information bias and confounding (127).

6.4.3.1 Selection bias

The studies included in this thesis are all based on birth cohorts including almost the entire Swedish male population who were alive and Swedish residents at the time for conscription examination. Non-participation is due to missing data on one or more of the variables used. If the occurrence of missing data is correlated to BMI-status and socioeconomic position this might generate bias in the results. As shown in the Results section a large proportion of individuals who had missing data from the Military Service Conscription Register did so due to technical/administrative problems unrelated to the information about outcome variables and potential confounding factors in other registers. Thus, it seems reasonable to conclude that selection bias is a minor problem in this thesis.

6.4.3.2 *Information bias*

All information in this thesis is gathered from Swedish national registers. Classification bias within the registers can be assumed to occur but in small scale and being non-differential. In general, the quality of the registers is good.

6.4.3.2.1 Classification bias of the exposure

The hypothetical exposure variable in this thesis is obesity developed in adolescence. When measuring obesity with the BMI classification bias is inevitable since the BMI concept does not allow a distinction between different body compartments, i.e. fat mass and lean body mass (including muscles and skeletal compartments). This classification bias may be assumed to be non-differential in relation to outcome variables. If this assumption holds, the estimates should be attenuated towards the null.

Obesity was measured at age 18-20, however, since obesity is tracking over time those classified as exposed can be assumed to be truly exposed at time of follow up (high sensitivity) (34). However, most people increase in BMI during adulthood and some who are obese in middle age might have been normal weight or overweight at baseline. In this perspective, a proportion of the men exposed at follow-up were classified as unexposed (lower specificity). However, although longitudinal information on BMI would have been an asset, it is a great strength that BMI was measured in late adolescence, at the same age for all individuals, before socioeconomic position was measured, thus minimizing the importance of reverse causality (as discussed above). In summary, misclassification of BMI can be assumed to only attenuate the estimated associations towards the null.

6.4.3.2.2 Classification bias of the outcomes

Information on education can be assumed to be of high quality since all Swedish universities report to Statistics Sweden by law. Misclassification is unlikely to be a major problem but may occur, especially if education has been attained abroad. Potential misclassification of education is most likely non-differential in relation to exposure (BMI) and estimates are expected to be attenuated towards the null.

The classification of socioeconomic position might be more problematic. The status of different occupations, and their educational need, may change rapidly and some misclassification is likely. If obese men were prone to chose occupations that are more often misclassified, the estimates might be distorted away from the null. However, such differential misclassification is likely to be of small magnitude and thus of minor importance.

Classification of income is probably less prone to bias. However, individuals with higher salaries might be engaged in tax avoidance schemes lowering their reported salary. These individuals are also less likely to be obese since obesity is correlated to socioeconomic position (as previously described). If this differential misclassification is an issue the estimated associations would be distorted towards the null.

Information on disability pension can be regarded to be accurate and of high quality. The classification is associated with governmental subsidies on the individual level and the control is high.

6.4.3.2.3 Classification bias of potential confounders

If misclassification of possible confounders occurs, residual confounding will remain and may produce bias in any direction. Confounding will be further discussed in the next section.

6.4.3.3 *Confounding*

Confounding arises when a factor is associated with the exposure and the outcome but is not a mediating factor (127). Confounding may produce bias in any direction. Both measured and unmeasured confounding will be discussed below. Variables suspected to be confounders were selected to be included into the multivariate models on the basis of known or putative mechanisms and their effects on the main association.

6.4.3.3.1 Measured potential confounders

Several possible confounders were accounted for in the analyses such as conscription office, municipality, age, birth year, height, marital status, intelligence, parental education and parental occupation.

Residual confounding cannot be excluded. The amount of residual confounding depends on how well the confounders were measured. The most difficult variable to account for in the analyses might be childhood socioeconomic circumstances since aspects of the concept associated with BMI, such as life style and values, might not be fully captured by parental education and occupation. However, results in paper IV using a matched sibling design provided strong support for the interpretation that although some residual confounding might be present in studies I-III, an independent effect of obesity on socioeconomic status in later life exists.

6.4.3.3.2 Unmeasured potential confounders

Several unmeasured factors may operate as confounders. It might be speculated that personal characteristics, such as self esteem and aspirations, are associated with obesity and risk factors for socioeconomic consequences. Nevertheless, most studies of psychological correlates of obesity in the general population have found obese not to differ from the normal weight individuals. An often cited early review stated that obesity seems to be unrelated to psychological problems in the general population (128). Body-esteem is generally lowered with increasing BMI but global self-esteem measures have not been found to be correlated with BMI in the general population (70). In a small prospective study of 1 278 adolescents, low self esteem among males was not related to longitudinal change in BMI (129). In conclusion, low self-esteem may act as a confounder in subgroups but may not be a problem in analyses of the general population. In a study of young women, aspirations to further education was lower among obese women than among normal weight women (130). It is, however, difficult to disentangle the causal relationships. If the lower aspirations and/or lower self esteem are consequences of the obesity rather than just associated with obesity these phenomena might be mediating factors between obesity and socioeconomic consequences (as discussed later).

Medical problems that are associated with obesity and risk factors for socioeconomic positions might act as confounders. Depression has been found to be associated with obesity in many patient studies, although not in the general population (128). Further,

depression has been reported to be associated with low socioeconomic positions in several studies according to a recent review (131). However, depression was not associated with attainment of low socioeconomic position in one longitudinal study (132). Thus, it is uncertain if depression can be considered to act as a confounder.

6.4.4 Methodological considerations in summary

The estimated associations between obesity and socioeconomic characteristics in later life are not likely to be explained by bias. Precision of most estimates were high and a high participation rate and objective measurements diminishes the importance of selection bias and information bias. Residual confounding may be present in some analyses but are unlikely to completely explain the observed associations between BMI status in late adolescence and socioeconomic characteristics in later life. Thus, associations between obesity and socioeconomic characteristics exist in this population of Swedish men and it is important to discuss why.

6.5 POSSIBLE MECHANISMS BEHIND THE MAIN FINDINGS

When presented with the results from studies I-IV some of the most likely explanations to the association between obesity and socioeconomic consequences have been taken into account in the analyses. Differences in intellectual capacity, family background, parental occupation, parental education, genetic background and place of residence could explain only a part of the differences in socioeconomic characteristics between obese and normal weight Swedish men. Neither is bias a likely explanation to the results of this thesis.

However, study IV offers some guidance as to look for explanations in the non-shared environment. What mechanisms that might explain the associations can only be speculated upon but medical complications of obesity or societal phenomena, such as discrimination, are likely candidates.

6.5.1 Medical mechanisms

One of the most important potential mechanisms behind the association between obesity and socioeconomic characteristics are comorbidities of obesity. As mentioned in the introduction, non insulin dependant diabetes mellitus, cardiovascular diseases, hypertension, gallbladder disease, and certain types of cancer were all important consequences of obesity (25). Comorbidities of obesity increase with increasing BMI and increasing age. If the association between obesity and socioeconomic consequences is mediated by co-morbidities of obesity, health selection might occur, as mentioned in the introduction.

The association between obesity and disability pension ought to be explained in full by medical complications of obesity according to legislation. However, a decision to grant a disability pension reflects, besides an underlying health condition, a judgment about impaired ability to work. If obese individuals are perceived to be less capable to work, by physicians issuing certificates or by social insurance officers, they might be excluded from working life more often than might be explained by their degree of disability. Previous research has found that some physicians express negative attitudes towards obese patients (4;133). A study from Finland showed that only half of the association between weight and sickness absence could be explained by measures of general health (92).

Medical complications of obesity might explain the association between obesity and income. Obese men have more sickness absence than normal weight men (89-93). When being sickness absent, income is lowered and thus obese men might have lower income due to sickness absence. Medical complications of obesity may certainly also be a mechanism behind the lower socioeconomic positions of obese men. Elevated sickness absence might lower the career opportunities of obese men. Comorbidities might also lower the ability to work, as well as the aspirations to have a successful career.

6.5.2 Societal mechanisms

In an early review of obesity and socioeconomic characteristics Sobal suggested that obese people are exposed to stigmatization and discrimination in societies where thinness is the norm (73). However, stigmatization of the obese is not new, one review showed that obesity might have been stigmatized already in medieval times (134). A recent population based study from the USA reported that obese individuals perceived that they were targets of discrimination (135). Discrimination might be divided into internalized discrimination, practiced by the individual himself, and external discrimination, practiced by individuals, and institutions, within the society (136-138).

6.5.2.1 Negative attitudes towards obese individuals

To my best knowledge no research on negative attitudes towards obese individuals from Sweden have been published, however, international research suggests that negative attitudes towards obese individuals are founded early. In a famous study from 1961, children were asked to rank pictures of children with different disabilities according to whom they would like to have as friends. The study showed that the obese child was placed last (139). A recurrence of the study conducted 40 years later showed that attitudes towards obese children had become even more negative (140). Other studies from the USA indicate that obese children often get bullied in school (141;142). Children that believed obesity to be under personal control were more negative to obese youngsters than children that believed obesity not to be the result of a personal decision (143). Previous research has found that negative attitudes towards obese individuals are widespread in the society (4). One study even reported negative attitudes towards obese individuals among health professionals specializing in obesity (133). Also primary care physicians and nurses have been reported to hold negative attitudes towards the obese (144;145). The beliefs that obese individuals are lazy, stupid and have lower working ability may lead to stigmatization and discrimination in schools and employment settings.

6.5.2.2 External discrimination

A thorough review from 2001 stated that discrimination of obese individuals occurs in schools, health service and employment settings (4).

Teachers are important gatekeepers for future socioeconomic position. One study reported that teachers believed obesity to be under individual control and the teachers agreed that obese children are untidy, more emotional, less likely to be successful, and more likely to have family problems (146). Additionally, 28% of the teachers agreed that becoming obese is one of the worst things that can happen to a person (146). Further, teachers might expect less from obese pupils and might not encourage obese pupils as much as they encourage normal weight pupils. Studies from the US

have shown discrimination against obese adolescents in college admission and parents willingness to pay for their children's education (147;148). However, this scenario is less likely in Sweden since university educations are free of charge and university admissibility criteria are mostly based on school marks. Nevertheless, the result of study I that few obese young men start a university education compared to normal weight young men and even fewer men graduate indicates that discrimination might occur within Swedish universities.

Studies from the USA describe discrimination of the obese in working life (4). Prejudice, indicating distaste for obese employees, might be held by employers (4;82). Employers might also hold stereotypes indicating a lower productivity of obese men or be less certain of the level of productivity of obese men, so called statistical discrimination (149). In the case of statistical discrimination information on the increased risk of sickness absence and disability pension might be rationally taken into account by employers thus creating a segregated labour market. However, one study reported that employees believed obese men to have more non medical related absence than normal weight men only (124). A study on the association between obesity and income disadvantage found no evidence that it would be mediated by health limitations or customer discrimination and speculated that discrimination in training opportunities or lower productivity among the obese might be important (81).

Studies of simulated employment interviews have shown obese subjects to be considered less attractive as future employees (123). Additionally, obesity in adolescence resulted in lower socioeconomic position even though adjustments for intelligence and parental socioeconomic position were made (74). Gortmaker et al found large socioeconomic consequences of overweight among women in a seven year longitudinal study, however, men were only found to be less likely to be married (76). Gortmaker et al found no effect of overweight on self-esteem and concluded that discrimination could be an explanation for their results (76).

6.5.2.3 Internalized discrimination

Obese individuals might perceive themselves, and other obese individuals, as being less valuable and inferior to normal weight people (71;136;137). Low expectations and negative attitudes towards obesity in the society might be internalized by obese individuals and low self-esteem might be a cause as well as a consequence (71;150;151). A meta-analysis from 1999 suggested that obese individuals have lower levels of self-esteem and speculated that this was a consequence of the obesity prejudice (71). Low self-esteem among obese individuals might affect the performance in the educational system and performance on the labour market and create an invisible barrier for attainment of a higher education/socioeconomic position. In one cross-sectional study, obese adolescent boys were more likely to believe they were poor students, more prone to expect that they would drop out of school and also more likely to being held back a grade compared to their normal weight peers (152). They did not, however, dislike school to any greater extent than their peers (152). As previously described, aspirations to further education was lower among obese than among normal weight individuals in a study of young women (130). Pagán and Dávila speculated that obese men might sort themselves into occupations of lower status if these occupations have smaller wage penalties for the obese (85). Thus, internalized discrimination may, in part, account for the difference in socioeconomic positions.

Internalized discrimination might also play a role for the attainment of disability pension. Obese subjects may themselves apply for disability pension more often than would be expected from their degree of disability. Research has shown that the attitudes of patients seeking a disability pension have impact on the physician issuing the certificates that are important in the decision to grant or not to grant disability pensions (153).

6.5.3 Possible mechanisms in summary

In conclusion, comorbidities of obesity most certainly are important mediators of the association between obesity and socioeconomic consequences. External discrimination has been shown to be a mediating factor in international studies and is most likely of importance in Sweden as well. Internalized discrimination probably affects the choices made by obese men in Sweden. The association between obesity and educational attainment can be hypothesized to be mediated, at least in part, by internalized discrimination.

6.6 UNDERWEIGHT

The scope of this thesis has been to investigate the associations between obesity and socioeconomic consequences, however, significant results for underweight men have also been found. Underweight men are less likely to attain a higher education and more likely to attain a disability pension in comparison with normal weight counterparts. Underweight men also had a significant increased risk of downward mobility compared to normal weight men. These findings are in accordance with earlier research showing socioeconomic disadvantage of thin men (154). The mechanisms behind these findings might, however, be different from the findings on obesity. A study among Swedish women found underweight women to have worse self reported global and psychological health than both normal weight and overweight/obese women (155). The aetiology of underweight is also different from that of obesity. The reasons for social disadvantage of underweight men are probably different from that of obese men and will not be further discussed within this thesis.

6.7 IMPLICATIONS

The results of this thesis show that Swedish men that are obese in late adolescence become socioeconomically disadvantaged later in life. The results cannot be generalized to women since they are not included in the study population. Socioeconomic consequences of obesity can, however, be speculated to be worse for women than for men, as previously reported in other studies (75;76). The results add justification to the importance of preventing obesity.

6.7.1 Implications for future research

In my opinion research on socioeconomic consequences of obesity among Swedish women should be prioritized in the future. One study on socioeconomic consequences of obesity among women do exist but the results need confirmation by other studies (20). The Medical Birth Register contains height and weight on all pregnant women since 1983 and may be used as a resource for such research. However, data on height or weight is missing for approximately 20% of the women in the Medical Birth Register, the women are of differing ages and only child bearing Swedish women would be included. Research should also focus on the mechanisms of the association between obesity and socioeconomic consequences. Perception of discrimination among obese individuals, as well as attitudes towards obese individuals among

professionals in the educational system, the labour market, and the health system may be studied.

6.7.2 Societal implications

The results of this thesis should be of use in the educational system and for the parties on the labour market. However, to be able to draw solid conclusions if the results are to lead to changes in the educational system, labour market or in the insurance system, further understanding of the causal pathways including mediating factors between obesity and socioeconomic position in later life are needed.

6.8 CONCLUSIONS

The results of this thesis show that obesity in late adolescence generates socioeconomic consequences in later life. Explanations for these consequences may be sought in the non-shared environment and are speculated to be co-morbidities of obesity, personal characteristics of obese individuals, or factors on the societal level such as discrimination.

7 SAMMANFATTNING [SUMMARY IN SWEDISH]

Syftet med denna avhandling var att studera om fetma i sena tonåren medför sociala konsekvenser senare i livet bland svenska män. Sambanden mellan fetma vid månstring och senare utbildning, yrke, inkomst och social mobilitet har studerats bland svenska män födda 1951-1979 som genomgick månstring vid 18-20 års ålder.

Studiepopulationen identifierades i flergenerationsregistret och kunde sedan genom samkörningar följas upp i registret över totalbefolkningen, pliktverkets inskrivningsarkivregister, folk och bostadsräkningarna, den longitudinella databasen kring utbildning, inkomst och sysselsättning, dödsorsaksregistret, patientregistret, registret över betyg i årskurs 9, registret över avgångna från gymnasieskolan, svenska tvillingregistret och studien av unga svenska manliga tvillingar.

Sambanden mellan fetma och senare socioekonomiska karakteristika skattades med statistiska modeller såsom logistisk regression, polytom logistisk regression och Cox regression i hela populationen samt med linjär regression och betingad logistisk regression bland brödrapar i populationen.

Resultaten visar att svenska män som var feta vid 18 års ålder inte skaffar sig en hög utbildning lika ofta som män som var normalviktiga. I jämförelse med normalviktiga män påbörjar feta män en högre utbildning 40 % mer sällan (hasard kvot 0.63 95 % konfidens intervall 0.60; 0.66) och avslutar en högre utbildning 50 % mer sällan (hasard kvot 0.48 95 % konfidens intervall 0.44; 0.52). Feta män har dessutom oftare en neråtgående social mobilitet och mindre ofta en uppåtgående social mobilitet i jämförelse med normalviktiga män. Dessutom drabbas de av förtidspension senare i livet 35 % mer ofta än normalviktiga män (hasard kvot 1.35 95 % konfidens intervall 1.19; 1.52). Dessa skillnader beror inte på olikheter i föräldrars yrke, föräldrars utbildning, egen intelligens, bostadsort, eller familjebakgrund och genetiska faktorer som delas av bröder.

Sammanfattningsvis visar denna avhandling att fetma i sena tonåren medför sociala konsekvenser senare i livet bland svenska män. Troliga förklaringar till dessa resultat är följsjukdomar av fetman, personliga karakteristika hos feta män såsom lägre ambitionsnivå och/eller lägre självförtroende, samt faktorer i det omgivande samhället såsom diskriminering.

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