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Leibniz University of Hannover and IZA

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Health and Body Mass Index: No Simple Relationship

Many studies have shown that obesity is a serious health problem for our society. Empirical analyses often neglect a number of methodological issues and relevant influences on health. This paper investigates empirically whether neglecting these items leads to systematically different estimates. Based on data from the German Socio-Economic Panel, this study derives the following results. (1) Many combinations of weight and height lead to the same health status. (2) Obese people have a significantly worse state of health. (3) The hypothesis has to be rejected that weight is an exogenous influence on health. (4) High income helps to improve men's health while deviations between desired and actual working hours induce negative effects. (5) The more siblings a woman has and the lower her father's social status, the worse is her health status. (6) Smoking is not good for health, a well-known fact. Especially for underweight individuals we detect the negative influence on health. Women are less affected. (7) A healthy diet strengthens the resilience for individuals who are not obese. (8) Long but not too long sleeping hours and sporting activities during youth contribute to a good health status. (9) Weight fluctuations induce negative effects on the health of women only. (10) Four of the big five components of personality, namely openness, extraversion, conscientiousness and agreeableness, contribute to resilience against health problems for underweight people.

JEL Classification: D03, I12, J16, J24, J81

Keywords: health, body mass index, underweight, obesity, gender, resilience, vulnerability

Corresponding author:
Olaf Hübler
Institut für Empirische Wirtschaftsforschung
Leibniz Universität Hannover
Königsworther Platz 1
30167 Hannover
Germany

E-mail: huebler@ewifo.uni-hannover.de

1 Introduction

Overweight, especially obesity but also underweight are globally discussed issues. The major studies on this topic come from the medical literature. However, economists also follow similar issues with a differentiated focus. Especially, the relationship between obesity and labor market outcome is analyzed (Johansson et al. 2009, Sabia/Rees 2012). Ensuing health problems and their economic consequences have been widely discussed with various studies mentioning serious health implications including higher mortality risk and health problems like cardiovascular disease, heart attack, stroke, diabetes, cancer, arthritis, gallstones, asthma, cataracts, infertility, snoring and sleep apnea – see e. g. , Eliassen et al. (2006), Flegal et al. (2013) and Willett et al. (1995). The Global BMI Mortality Collaboration (2016) has found from a worldwide investigation that both overweight and obesity were associated with increased all-cause mortality. Men have almost double the proportional excess mortality of women. On average, overweight people lose about one year of life expectancy, and moderately obese people lose about three years of life expectancy.

Most studies present their results with the help of descriptive and multivariate statistics. Weight is usually measured in kilograms, expressed by weight groups or by the body mass index (BMI). Most studies assume a linear relationship between health and weight and draw far-reaching conclusions in relation to preventive measures. Normally, authors do not pay enough attention to differences between men and women and country-specific peculiarities. Many investigations also neglect interdependencies, measurement errors and unobserved influences. Medical studies on the one hand and socio-economic investigations on the other hand should not ignore the results from the other discipline. Specific individual behavior and characteristics, including those developed during youth, are important. All these aspects contribute to the outcome that current connections are not stable and insignificant, that some persons or groups exhibit different results and that individual behavior can strengthen resilience against diseases or increase the vulnerability. So far, it appears that a strong awareness campaign and public health policy against extreme body weight can avoid a lot of health problems. However, we find that we need specific measures for specific groups.

This paper extends the literature in the following ways: (i) it consistently separates effects by gender, (ii) it takes into account unobserved heterogeneity and interdependencies; (iii) it extends the use of weight groups beyond the traditional international BMI classification instead also using quantiles of the German weight distribution; (iv) it analyzes the importance of personality characteristics and behavior, especially the link between the Big 5 factors, for resilience to various health problems.

2 Related literature

We focus on studies of the relationship between weight and health. The major studies on this topic come from the medical literature. However, economists also follow similar issues with a differentiated focus depending on whether developing or developed countries are the focus of the study.

Empirical studies find a positive correlation between body mass index and health status in developing countries: Kennedy and Garcia (1994) explore a relationship between low BMI and illness patterns in Pakistan, Kenya, Philippines and Ghana. Significant but only small effects are detected in Pakistan and

Kenya. Moreover, the circularity between low BMI and illness has to be stressed. The authors review a positive link between nutritional status and productivity in African countries although their research relating nutritional to work capacity is more conclusive.

Most people believe that being taller and heavier is a sign of higher social status and privilege. However, Samaras (2012) demonstrates that objective evaluation of the advantages and disadvantages of increased body size (excluding obesity) indicated that shorter, smaller bodies have numerous advantages in terms of health and longevity. Given healthy nutrition and lifestyles as well as good medical care shorter people are less likely to suffer from age-related chronic diseases and more likely to reach advanced ages. He argues that a variety of biological factors explain the inherent benefits of smaller bodies: These include reduced cell replication, much lower DNA damage and reduced cancer incidence.

In many Western countries the average weight of people has increased substantially in recent years and has led to health problems. However, declining mortality risk over time due to better control of risk factors for heart disease (Gregg et al. 2005) can be observed. Nevertheless, this development has not led to reduced disability risks (Alley and Chang 2007). Oswald and Powdthavee (2007) following Offer (2006) argue that economic prosperity undermines well-being. Happiness and mental health are worse among heavier people in Britain and Germany. For a given level of BMI they find that people who are educated or who have high income are more likely to recognize themselves as being overweight or even as obese.

Soltoft et al. (2009) analyze the relationship between weight, measured by the body mass index, and health-related quality of life using data from the Health Survey for England 2003. They find a nonlinear link. The best quality of life was reached at a BMI of 26.0 in men and 24.5 in women. This means that BMI is negatively associated with quality of life for both underweight and obese individuals. At higher BMI values, men reported higher quality perceptions than women. At lower BMI values, the reverse result is observed: Quality of life is lower in men than women.

The aim of another study (Psouni et al. 2016) is to characterize the patterns of psychological and behavioral characteristics, in relation to body mass index. The analysis is based on 361 Greek adults, randomly selected who completed self-reported questionnaires. Cluster analysis identified two distinct profiles: the first segment relates to more positive results in psychological variables. Interestingly, individuals in the healthy segment correspond to a normal body mass index (BMI). The second segment relates to more unhealthy behaviors including lower levels of exercise, unhealthy eating and negative psychological variables. As expected, individuals in the second segment had a mean overweight BMI. Furthermore, profiles from the unhealthy segment displayed higher levels of psychological distress and lower self-control.

Lissner et al. (1991) demonstrate that fluctuations in body weight have negative health consequences, independent of obesity and the trend of body weight over time. Preston et al. (2012) confirm this result. They find that higher volatility and increasing trends have large negative effects on mortality for obese people. Bhattacharya and Sood (2011) argue that body mass index should not be regarded as a medical diagnosis: Many classified as “obese” are physically fit as several studies make clear.

Dunson et al. (2007) show, that there is a significant relationship between body mass index (BMI) and luteinizing hormone (LH) for women. Graphs present the estimated predictive density of BMI for LH values corresponding to different percentiles of the empirical distribution, with age fixed at the sample mean value. To assess interactions with age, they show plots for age fixed at a low or high value. Their results suggest that obese women, particularly morbidly obese women, tend to have low LH levels. This goes against the hypothesis that obese women may be at greater risk of uterine smooth muscle cell proliferation and fibroid development due to increased LH. However, it is consistent with a second hypothesis that obese women may have diminished reproductive functioning, which is linked to low LH levels. Altogether, they show that there is a decreasing trend in mean BMI with increasing LH levels, with the non-linear curve flattening out at higher LH levels.

Bray (2004) describes the medical consequences of obesity in the following way: obesity is an epidemic disease that threatens to inundate health care resources by increasing the incidence of diabetes, heart disease, hypertension, and cancer. These effects of obesity come from two factors: the increased mass of adipose tissue and the increased secretion of pathogenetic products from enlarged fat cells. This concept of the pathogenesis of obesity as a disease allows an easy division of disadvantages of obesity into those produced by the mass of fat and those produced by the metabolic effects of fat cells. The former category contains the social disabilities coming from the stigma associated with obesity, sleep apnea that comes in part from increased parapharyngeal fat deposits, and osteoarthritis resulting from the wear and tear on joints from carrying an increased mass of fat. The second category includes the metabolic factors associated with distant effects of products released from enlarged fat cells. The insulin-resistant state that is so common in obesity probably reflects the effects of increased release of fatty acids from fat cells that are then stored in the liver or muscle. When the secretory capacity of the pancreas is overwhelmed by battling insulin resistance, diabetes develops. The release of cytokines from the fat cell may stimulate the proinflammatory state that characterizes obesity. The increased secretion of prothrombin activator inhibitor may play a role in the procoagulant state of obesity. For cancer, the production of estrogens by the enlarged stromal mass plays a role in the risk for breast cancer.

Most of these studies suffer from methodological shortcomings. They do not consider any or only a limited number of control variables. They focus on linear a relationship or specific explanations. They do not discuss interdependencies between health and weight and they neglect personal characteristics and behavior as determinants of the relationship between BMI and health.

3 Data and methods

3.1 Data

The data set used in this study, the German Socio-Economic Panel (SOEP), is a representative annual household survey started in 1984 covering Western Germany at the time that was extended to Eastern Germany in 1990 (Wagner et al. 2007). Our sample covers the years 2004, 2006, 2008, 2010 and 2012. The individuals report their weight and height. In 2004, the sample contained 11,796 households and 22,019 individuals. Respondents are included in the respected sample if information about health and other necessary characteristics like wage, schooling, gender, age, height, father's prestige score (Treiman 1977), mother's schooling, number of siblings and body mass index is available. Table A1 presents descriptive statistics for all utilized variables. The number of observations differs for different variables due to varying determinants and missing values of the applied variables.

Different health indicators are available from the survey. The most commonly used variable measures subjective answers evaluated on a five-stage rating scale. Health (h1)= 1 means that the current health is very good, while h1 = 5 expresses that the individual current health is bad. This is a quasi-continuous variable so that OLS can be applied. Alternatively ordered probit estimates can be used or the rating scale can be transformed into a completely continuous variable before OLS is applied (van Praag and Ferrer-I-Carbonell 2004).

Weight is measured by the body mass index (BMI=weight in kg/(height in cm/100)²). Subgroups are constructed following Costa (2015): “underweight” (BMI<18.5 kg), “normal weight” (18.5<=BMI<25), “overweight” (25<=BMI <30), “obesity 1” (30<=BMI<35) and “obesity 2” (BMI>=35). Sometimes the obesity class is treated as one while the WHO (2000) suggests a more disaggregated classification of obesity into four classes and writes (p.9): “These BMI values are age-independent and the same for both sexes. The table (BMI classes) shows a simplistic relationship between BMI and the risk of comorbidity. The risks associated with increasing BMI are continuous and graded and begin at a BMI above 25.”

Big five personality traits (Big 5) are calculated from answers to question 151 in SOEP2013. Interviewees were asked in relation to a total of 16 topic areas. On a scale from 1 to 7 (=1 if does not describe at all, … , =7 if describes perfectly) they answered by giving their subjective assessment of individual personality. The same items were collected in 2005 and 2009 and the results are very similar. All big five factors – “openness”, “extraversion”, “conscientiousness”, “agreeableness” and “neuroticism” – are determined as the sum of the scores generated from answers to three questions. This means the minimum score for each factor is equal to three and the maximum score is equal to 21. This distribution can be seen in Table A1. “Openness” characterizes people who are original, have new ideas, who have artistic and aesthetic experiences and are imaginative. “Extraversion” describes persons who are communicative, talkative, who are outgoing and sociable and who are not reserved. Typical traits for persons with “conscientiousness” are that they are thorough workers, that they are not lazy and that they are effective and efficient in completing tasks. The fourth characteristic, “agreeableness”, expresses that people are not rude to others, that they can forgive and that they are considerate and kind to others. Individuals who are easily worried, who are nervous in many situation and who are not easily relaxed and cannot deal with stress well exhibit the fifth property, “neuroticism”.

3.2 Empirical strategy

In the literature we observe different health and weight indicators. It is unclear whether they measure the same things and whether there are significant differences between men and women. Health can be evaluated based on subjective valuations or objective facts. First, we test whether the different available health indicators correlate significantly using simple correlation coefficients (see Table 1a and b), whether we can restrict the following econometric analysis on one health indicator.

We also note that weight depends on height and both characteristics can induce serious health problems: previous studies have not only observed a relation between weight and a range of disease outcomes but also between height and health (Batty et al. 2009). Therefore, it makes sense to combine both variables and / or to incorporate height as a determinant of weight. Most often, the body mass index (BMI) is used. In some sense this measure introduces a first step of nonlinearity. In a second step we test whether the incorporation of BMI^2 besides BMI improves health estimation. This can be driven by systematic gender differences and we prove this in Table 2. A more differentiated analysis can be based on weight groups, as mentioned in section 3.1. This approach allows the identification of the way, the health status varies between weight groups and between men and women. Overweight individuals are chosen as the base group (Table 4). Besides OLS we use ordered probit estimates as the regressand health is measured by an ordinal variable.

The data set is a panel so that unobserved heterogeneity measured by time-invariant individual effects can be controlled for. Therefore, we present random effects estimates in Table 5 including further control variables. Another methodological problem follows if health is not only influenced by weight but reverse causality is also possible. This issue can be resolved by simultaneous modelling. We address this issue in Table 6 where we use instrumental variable estimates. As there are no entirely convincing external instruments, we follow Lewbel (2012) in columns 1 and 2 and use gender specific BMIs. Specifically, those 10 percent of men and women respectively with the highest and lowest BMI are contrasted with the others as the base group. Instruments are constructed as simple functions of the model data. Identification is achieved by using regressors that are uncorrelated with the product of heteroskedastic errors. The greater the degree of scale heteroskedasticity in the error process, the higher will be the correlation of the generated instruments with the included endogenous variables. In columns 3 and 4, the continuous BMI variable is again substituted by BMI classes. Underweight and adipose people of class II, following the international classification of BMI, are contrasted with the others.

The next step tries to detect reasons that are responsible for some people not having health problems although they are underweight or obese as the graphs in section 4.1 demonstrate in a descriptive manner. In other words, we want to find explanations why some people outside the weight norm are more resilient to bad health than others. Conversely, individual behavior can also cause a tendency for poor health among persons classified as normal weight. In Tables 7a and 7b we show results that address this issue. On the one hand, weight is split in line with the internationally accepted classification. On the other hand, separate estimates are derived based on the empirical weight distribution in Germany. We construct three groups: i) people with a weight within the lower quartile referred to as light-weight, ii) those within the interquartile range – medium-weight - and iii) finally those within the upper quartile of the weight distribution – heavy-weight. This latter classification is based on the following presumption: The concepts of under-, normal- and overweight as well as obesity are not completely comparable across countries and longer time periods. Hence, we also use the German specific alternative as a robustness test.

Since many factors are strongly correlated, collinearity can become a relevant concern. Principal component analyses can bundle the influences with the aim of deriving uncorrelated components. The respective results are shown in Tables 8 and 9. We place particular emphasis on the importance of the “Big5” factors, a concept developed by the psychology of personality (McCrae & Costa 1997):

"openness", "conscientiousness", "extraversion", "agreeableness", and "neuroticism". These dimensions are commonly held to be a complete description of personality and the acronym OCEAN is often used.

4 Results and discussion

4.1 Descriptive results and graphs

(i) Health indicators

Over time the SOEP data set contains a number of different health indicators but not all information is collected every year. In 2012, seven variables are available: h1 – current health (=1 if very good, … , = 5 if bad); h2 – health satisfaction (=0 if completely dissatisfied, … , =10 if completely satisfied); h3 – problems at climbing several flights of stairs on foot due to the own health status (=1 if greatly, =2 if somewhat, =3 if not at all); h4 – problems at lifting something heavy or doing something requiring physical mobility (=1 if greatly, =2 if somewhat, =3 if not at all) ; h5 – suffering from any conditions or illnesses for at least one year or chronically (=0 if no, =1 if yes); h6 – total number of nights spent in hospital last year ; h7 – number of days unable to work last year due to illness. A further health indicator h8 is available based on 2013 data: Respondents were asked whether a doctor has found any chronical illness in the past (=0 if one or more diseases were found; =1 if no disease was detected). In Table A1 we show descriptive statistics, while Tables 1a and b show the simple Pearson correlation coefficients, broken down by gender. We can see that for h1-h5 the mean indicates health values that are a little bit better than one would expect under the assumption of an equal distribution. E. g., Table A2 shows mean(h1)=2.80<mean(h1|equal distribution)=3 and mean(h2)=6.42>mean(h2|equal distribution)=5.5. Note that for h1 the lowest value indicates best health while for h2 the highest value indicates best health.

Furthermore, we observe "underdispersion" for all indicators h1 through h5 relative to the assumption of a Poisson distribution (Cameron and Trivedi 1998) that is (variance/mean)<1. Table 1 demonstrates that the health indicators are significantly correlated with two exceptions, namely corr(h4(problems at lifting),h7 (number of days unable to work)) and corr(h7,h8(a doctor has found any chronical illness)) for women. In most cases the correlation coefficients are larger for women. No other systematic gender differences can be detected. The most powerful relations are revealed between current health (h1), health satisfaction (h2), problems at climbing several flights of stairs (h3) and problems at lifting something heavy (h4). We restrict the subsequent analyses on h1.

(ii) Weight indicators

Weight is measured by the body mass index (BMI). Most studies that use this indicator use the same boundaries for men and women, across different countries and for different periods of time. However, empirically obvious differences can be observed. For example, the comparison of the BMI distribution for men, aged 50-64 in Germany 2004-2012 averaged (SOEP- BMI<18.5: 0.4 %; >=18.5-<25: 26.4%; >25-<=30: 48.5%; >30-<=35: 19.1%; >=35: 5.6%) with the analogous distribution in the United States for the years 2005-2010 (see Costa 2015, p.520 or Table 3, Panel C for the distribution in the US: <18.5: 1.2 %;

>=18.5-<25: 17.8%; >25-<=30: 42.8%; >30-<=35: 24.4%; >=35: 13.8%) illustrates that American men are heavier than German men, that more of them are in the overweight class .

Table 2 shows results by gender for Germany. On average, men have a higher BMI. Following Costa's classification – see section 3.1 -, we recognize that most women belong to the normal weight class, while men are overrepresented in the overweight class. Only very few men are underweight. It is interesting to note that we find relatively more women than men in the obesity II class. The proportions are reversed within the obesity I group. The different BMI distributions for men and women suggest that empirical BMI quantiles separated by gender should be used for robustness analysis.

(iii) Distribution of body mass index for healthy and unhealthy people

Table 3, Panel A shows that (unsurprisingly) people with good health are over-represented in the normal weight class. Diseased people are over-represented in the obese classes. Hence we find that high BMI correlates with bad health. This result is confirmed in Panel B, where the micro census is used as an alternative and larger source. The comparison with the United States in Panel C demonstrates that country-specific weight distributions exist. The U.S. population is more overweight than the German population. Moreover, we can see from Panel D that older people have a stronger tendency to overweight and obesity.

(iv) Simple relationships between health, weight and height

Graphs 1 and 2 demonstrate the relationship between health and weight, namely between current health (h1) and BMI on the one hand and health satisfaction (h2) and BMI on the other hand. The second figure is in some sense the mirror image of the first figure. Apart from this distinction, the curve progression is very similar. Health dispersion is larger within the group of underweight and obese people relative to within the group of normal weight people. This finding supports the assumption that there specific individual behavior exists that has an impact on current health status. Factors of resilience and vulnerability may have an impact so that not all underweight and not all obese have health problems.

Among underweight men health status varies widely while women with a low BMI usually report that they feel fine. The obese segment is characterized by the fact that the same weight (expressed in BMI terms) is linked with better health for women than for men. The shape of the curve in Figure 1 and 2 illustrates a clear nonlinear link between health and weight.

The usual consideration of the link between health and BMI assumes a specific nonlinear relationship between weight and height, namely weight in kg / (height in cm/100)^2. A priori, it is not clear, whether this describes the correct interaction effects on health. Linear modelling

$$\text{health} = \beta_0 + \beta_1\text{weight} + \beta_2\text{height} + \varepsilon$$

excludes joint effects while a linear interaction model

$$\text{health} = \beta_0 + \beta_1\text{weight} + \beta_2\text{height} + \beta_3\text{weight}\cdot\text{height} + \varepsilon$$

only takes into account one specific interaction. One way to capture a more general nonlinear link is to use additive models (GAM, see Hastie and Tibshirani 1986, 1997). This means using the following relation:

$$(\text{health}|\text{weight, height}) = s\,(\text{weight, height}) + \varepsilon,$$

where s stands for a smooth function, i.e. a continuous but unspecified function of weight and height that is estimated from the data. We use a P-spline smoother for performing our empirical analysis (Marx and Eilers 1998). P-spline smoothing models are fitted using penalized likelihood maximization where the likelihood is modified by the addition of a penalty for each smooth function, the squared deviation between the true and the estimated $s(\cdot)$ function. The smoothness of $s(\cdot)$ is calculated with the objective of an optimal balance between the fit to the data and a penalty for excessive deviations between $s(\cdot)$ and $\hat{s}(\cdot)$. In this paper, we estimate the smoothing parameter using a restricted maximum likelihood (REML) approach (Ruppert et al. 2003; Wand 2003).

The graphical representation of the GAM estimates for women and men can be found in Figures 3 and 4. The tendency is not new: the shorter and heavier a person the worse is the status of health, i.e. the larger are the numerical values of h1. However, the iso-lines at the same health status demonstrate a wide range of weight and height combinations where we cannot discriminate the status of health. The heavier a person the less relevant the height component becomes for women. This outcome is not so clearly observed for men. Here, the data show a stronger interaction between weight and height, especially for heavy men. Within a range from 60 kg to 90 kg on the one hand and 180 and 200 cm on the other hand, the iso-lines look similar for both sexes. The shape within the yellow areas is uncertain because there only few observations determine the course of the health iso-lines. In contrast to this outcome we can be more confident in the red areas with many observations.

4.2 Nonlinear interdependent regressions and ordered probit panel estimates of health

Regressions of weight on health are usually restricted to simple linear models with a limited number of control variables at best, e. g. age, sex, race, education and income (Tomiyama et al. 2016, Alley and Chang 2007). In column 1 of Table 4, we present such an estimate with BMI as the weight measure. Alternatively, weight can be split into BMI classes (see Table 2), which leads to the estimation results in column 4. In both cases health status continues to deteriorate with increasing BMI, which is in line with earlier studies. As an alternative to Figures 3 and 4 (which used GAM models), nonlinearity between health and weight can be captured by adding a squared term of BMI (see Table 4, columns 2 and 3). For women we find a significant (negative) effect of the squared BMI term on health. However up until BMI=57.45, health nonetheless continues to worsen with increasing BMI. The results in columns 5 and 6, where BMI is split by five classes with overweight people as the base class, do not confirm the linear shape but instead confirm health is better at lower BMI values compared to higher ones.

The outcome changes completely when we add control variables or use panel estimates – see Table 5. In this case time-invariant individual effects are taken into account. In columns 2 and 3 the null hypothesis of no individual effects is rejected by a Breusch-Pagan test (χ^2_f=1063; χ^2_m=710). Under this specification we find merely linear BMI effects for women: Health status continually worsens with an increasing BMI.

Men show improving health up to a BMI=21.71. At higher BMI values, we notice a deterioration of the health status. Under fixed effects estimates which should be preferred based on the Hausman test (women: prob.value=0.0027; men: prob.value=0.0592) only linear significant BMI effects on health can be found. In this case BMI coefficients are very similar for women and men (0.0472 (t=4.19) and 0.0484 (t=3.90), respectively).

When sectors of employment dummies, annual dummies and further personal characteristics like age, schooling and wages are incorporated we find that deviations between desired and actual working hours have an adverse effect on health for men. Family characteristics such as the number of siblings and father's social status measured by the Treiman index should also be considered. Few siblings and high social status may contribute to better health although in our investigation the former effect is insignificant. Influences that are settled during childhood and adolescence are still effective for adults. Severe health problems are only revealed at people with obesity II as shown in columns 4 and 5. Health outcomes for other BMI classes do not significantly differ from the base category (overweight people) except for normal weight women. They display better health. In comparison with Table 4, we find weaker statistical relationships between health and BMI classes in Table 5. Unobserved influences are responsible.

Furthermore, waived interdependency between weight and health leads to biased estimates. Causality is not restricted from weight to health. Specifically chronic diseases and necessary drugs can increase or decrease weight. Detailed information about this relationship is only available in a small number of medical surveys where necessary personal details, characteristics and individual behavior are usually missing (Alley and Chang 2007, Bray 2004). We switch to instrumental variables estimates. In Table 6, Lewbel's approach is applied. Here, we focus our analysis on extreme weight ranges – underweight and obese people. In columns 3 and 4 the international BMI classification is applied. Conversely, in columns 1 and 2 we analyze the weight impact on the health of the 10 percent of people with the lowest and highest BMI respectively in comparison to the effect for people in the intermediate 80 percent of the BMI distribution. These percentiles are based on the German BMI distribution using SOEP data.

We also want to test whether the German BMI distribution deviates from the internationally defined BMI classes. Therefore, we compare columns 1 and 2 with columns 3 and 4. First, we find that the hypothesis of exogeneity is rejected in all four estimates – see line EXO. On average type II obese people display a significantly worse state of health while underweight people do not differ from normal and overweight people. However, in columns 1 and 2 we find different signs for men and women in the line for people with a BMI<=10 percentile. Underweight men tend to have worse health than normal and overweight men. This is not confirmed in column 4, line underweight. Two factors might be responsible: The "underweight" category includes BMI<=18.5 but the 10th percentile for women contains BMI<=20.3 while for men it contains BMI <=22.4. Hence it is possible that the sign change between men and women in the first line of Table 6 is determined by the BMI range from 20.3 and 22.4. However, no rational explanation is at hand for why this would be the case. It seems more likely that the relationship between health and weight (BMI) varies across gender that light weight men tend to have worse health than medium weight men while for women a reverse relationship seems plausible. This speaks in favor of the estimates in columns 1 and 2 in comparison to columns 3 and 4. A further advantage of using columns 1 and 2 is that the hypothesis of weak instruments is only rejected under this specification – see line STOCK-YOGO.

It seems also interesting to investigate the impact of control variables on health status, which differs between men and women: The higher the schooling the better is the health status. This is also confirmed by a report of the Institut der Deutschen Wirtschaft (iwd 2017) with the title: Intellectuals eat healthier. The effects are higher for women than for men. High income also helps to improve health but we find this effect only for men. Deviations between desired and actual working hours have a negative effect. For women no such influences can be detected. However, we observe two other effects that are absent for men: The number of siblings and a lower father's social status carry unfavorable health effects. We have the following possible explanations: (i) The higher the income, the more money is available for health expenditure. This should be true for both men and women. A priori, one would even expect the effect to be stronger for women because they are generally perceived to be more health conscious but women's income is on average lower, which limits the income available for health expenditure. In particular, single mothers who are working part-time spend their small wage growth for other things, namely for their children. (ii) Permanent involuntary overtime and working hours in excess of desired hours have negative long run effects on health. However recent research has shown that women have better opportunities for aligning actual and desired working hours via working time accounts (Hübler 2017) so that we expect a less and insignificant influence of deviations between desired and actual working hours on health status for women than for men. (iii) The social status of parents and the number of siblings are characteristics that shape health during childhood and youth. Low social and economic status is usually linked with low health awareness (Wardle/Steptoe 2003). The more children there are in the household, the more likely parents are to be limited in their ability to care adequately for their individual children. Health care is more likely to be neglected. However, it is not evident why girls should be underprivileged. It may be that the traditional family image with discrimination against girls in education and other fields is still dominant in families with low social status, which leads to early health problems continuing as an adult.

4.3 Resilience and vulnerability

In Figures 1 and 2 we have seen that the spreads of health outcomes in the tails of the BMI ranges for men and women are substantially more pronounced than in the intermediate range. This means that not all men and women with low or high weight display health problems. In other words, influences exist that render some underweight and obese people resilient against chronic or mental diseases while others are particularly vulnerable. In this section we look for personal characteristics and behavioral patterns that can potentially explain such individual differences. For the former we focus on the big five factors (see above). The latter field includes characteristics whether a person is a smoker, whether her diet is healthy, how long she normally sleeps but also activities during youth and whether weight fluctuates or whether it increases over time. Some further control variables that we have already used in estimates under 4.2 are included. In Table 7 the Big 5 variables are still suppressed; we focus on behavioral characteristics instead. Here we use international BMI classes but with underweight and normal weight aggregated into one group because the number of observations in the underweight category is too small to obtain estimates when many control variables are incorporated.

We confirm that smoking (=0 not currently; =1 yes currently) is not good for health, a well-known fact. This effect is particularly strong for underweight individuals while women are less affected on the whole. Lower smoking intensity may explain this outcome.

A healthy diet (=1 very strongly, … , =4 not at all) strengthens resilience for individuals who are not obese. Men's health status does not appear to benefit from a healthy diet when they have a BMI within the upper quartile. Instead we observe a negative relation for this group, a totally unexpected and counter-intuitive result. This result suggests that subjective and self-reported answers to the diet question may not necessarily be trusted. Perhaps, obese people lack the appropriate information on what constitutes a healthy diet or they are deluding themselves about how well they adhere to one.

Najib (2004) writes in a review that individuals who report both an increased (>8 h/d) or reduced (<7 h/d) sleep duration are at modestly increased risk of all-cause mortality, cardiovascular disease, and developing symptomatic diabetes. Our investigation illustrates that long sleeping hours contribute to resilience in general with two exemptions as our results make clear. First, for men this effect is only observed, when they are underweight. Second, the impact of sleep duration appears to be non-linear: The positive impact is reversed or weakened when sleep duration is too long. E. g. a sleep duration of nine hours is optimal for health of underweight women while all others need less sleep. Walch et al. (2016) find that women sleep longer than men.

Sporting activities (=0 if no sport activities; =1 sport activities) during youth also lead to better health outcomes that continue into adulthood. The group of obese II women is an exception. Musical activities (=0 no musical activities during youth; =1 musical activities) have also positively assessed in respect of good health.

In our final step we analyze the impact of Big5 variables capturing personality traits. We extend the model by including the generated variables "openness", "extraversion", "conscientiousness", "agreeableness" and "neuroticism". As several control variables are strongly correlated this inclusion leads to insignificant estimates. Therefore, we aggregate the variables using principal component analysis with varimax rotation and decide for the six component model. The six component model allows for the best interpretation – see Table 8 - and explains roughly 50 percent of the total variance. Based on factor loadings larger than 0.3, we interpret the components in the following way:

(1) OECA factor - four of the Big5 variables (openness, extraversion, conscientiousness and agreeableness – OECA) load high on this component.
(2) Success & confidence factor -the second component is mainly determined by low neuroticism, the fifth Big5 variable, self-confidence and income (gross wage).
(3) Health behavior factor - the third component loads high on the variables smoker, health diet, sleep duration and the difference between desired and actual working hours.
(4) Factor of early influences - musical and sporting activities during adolescence, schooling and undenominational are the most important variables for this component.
(5) Weight variation factor – weight fluctuations and weight's growth rate load high on the fifth component.

(6) Residual factor - the final component includes only two variables with high factor loadings, namely sporting activity and public sector employment.

In the next step, we incorporate the scores of the six orthogonal components into ordered probit regressions of health – Table 9. The main objective is to clarify which components best explain health for individuals with a BMI in the lower and upper quartile of the distribution. We find that the OECA component with openness, extraversion, conscientiousness and agreeableness contributes to resilience against health problems. Obese men are the only group for whom this link is not confirmed. When we consider the effects of the other principal components on general health status, we can say that on average:

- Absence of neuroticism combined with high income and self-confidence is good for health.
- Smokers who are less interested in a healthy diet, who have answered that their sleep duration is short and who cannot bring their desired and actual working hours in line are vulnerable to diseases.
- Influences that impacted during adolescence ("early influences") are positive for the health of underweight individuals while the effects for overweight individuals are mixed.
- Weight fluctuations, especially weight growth, seem positive for the health of individuals with low BMI.

No clear interpretation is possible for the residual component. This could support a five-component model. However, preliminary investigations into a possible five component model show that the interpretation of the resulting five components is less straightforward than that of the first five components in our preferred model. A seven component model leads to similar results but comes with some interpretation problems. While the first two components are identical to ours the health variables are not bundled in one component but split in two components. The "early influences" component does not include schooling. The sixth component includes sporting activities during adolescence, public sector employment in the sense of the non-market factor but also the weight fluctuation variable, which makes it impossible to ascribe any systematic relationship to this combined variable.

5 Conclusions

The major results of this study are the following:

- The relationship between health and weight differs for men and women in many aspects.
- The consideration of country-specific BMI-distributions is advantageous.
- A wide range of weight-height combinations is consistent with the same health status.
- Well-known health indicators correlate strongly with one another allowing the researcher to focus on one health indicator only.
- Different effects of income, working hours and parental social status can be detected for both sexes.
- Strong obesity but not slight adiposity and not underweight are usually connected with bad health.
- Smoking is clearly not good for the health. For women, this result is less pronounced.

- In general, a healthy diet strengthens resilience against diseases but for obese people this link is not so obvious.
- Sporting activities and long but not excessive sleeping hours improve the chances of good health. Men and women on the one hand but also underweight and obese people on the other hand are not affected to the same extent.
- Personality traits measured by the Big Five model taken from personality psychology can be shown to be important for the explanation of vulnerability and resilience against health problems. Openness, extraversion, conscientiousness and agreeableness contribute to resilience against health problems. Absence of neuroticism combined with high income and self-confidence is in general good for health.

Our investigation has shown that “differences in weight and adjustments to one’s weight only partially explain and affect health problems.” A lot of innate and acquired characteristics determine whether a move towards one’s “optimal” weight is successful in improving health outcomes. The link between health and body mass index is no simple relationship.

We need a more group-specific health policy and the individual willingness to go against the laziness eliminating vulnerabilities like smoking. To the extent possible, future studies with better data should consider unobserved family and genetic information as Böckerman/Maczulskij (2016) have done for the analysis of the education-health nexus. Furthermore, the incorporation of individual medical histories can be helpful to uncover determinants of vulnerability against health risks.

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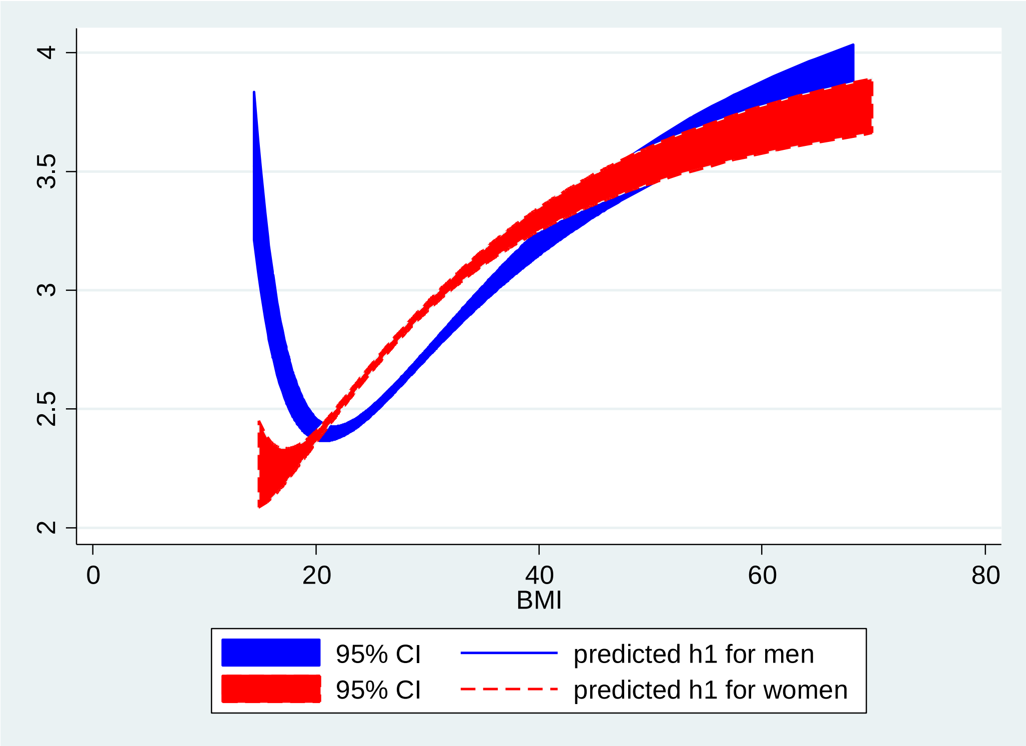
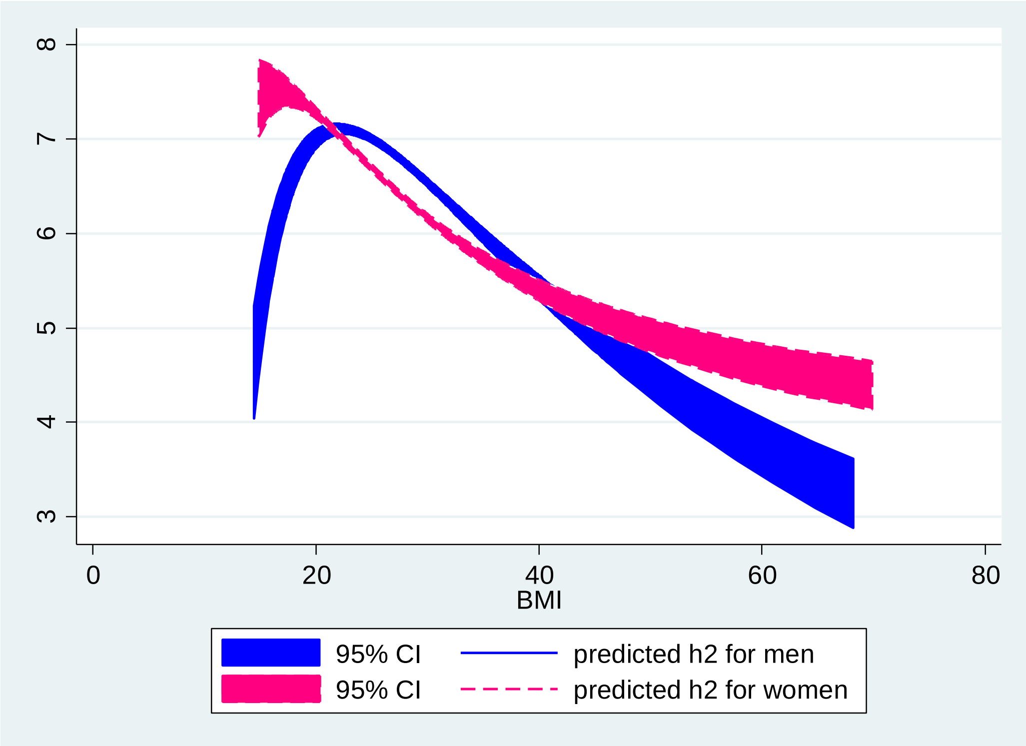


Notes: health=1 if very good, … , =5 if bad.

Fig. 1. **Weight effects on health (h1), measured by BMI and subjective status of health, broken by gender**



Notes: health=0 if completely dissatisfied, … , =10 if completely satisfied.

Fig. 2. Weight effects on health (h2), measured by BMI and subjective degree of satisfaction with health, respectively, broken by gender

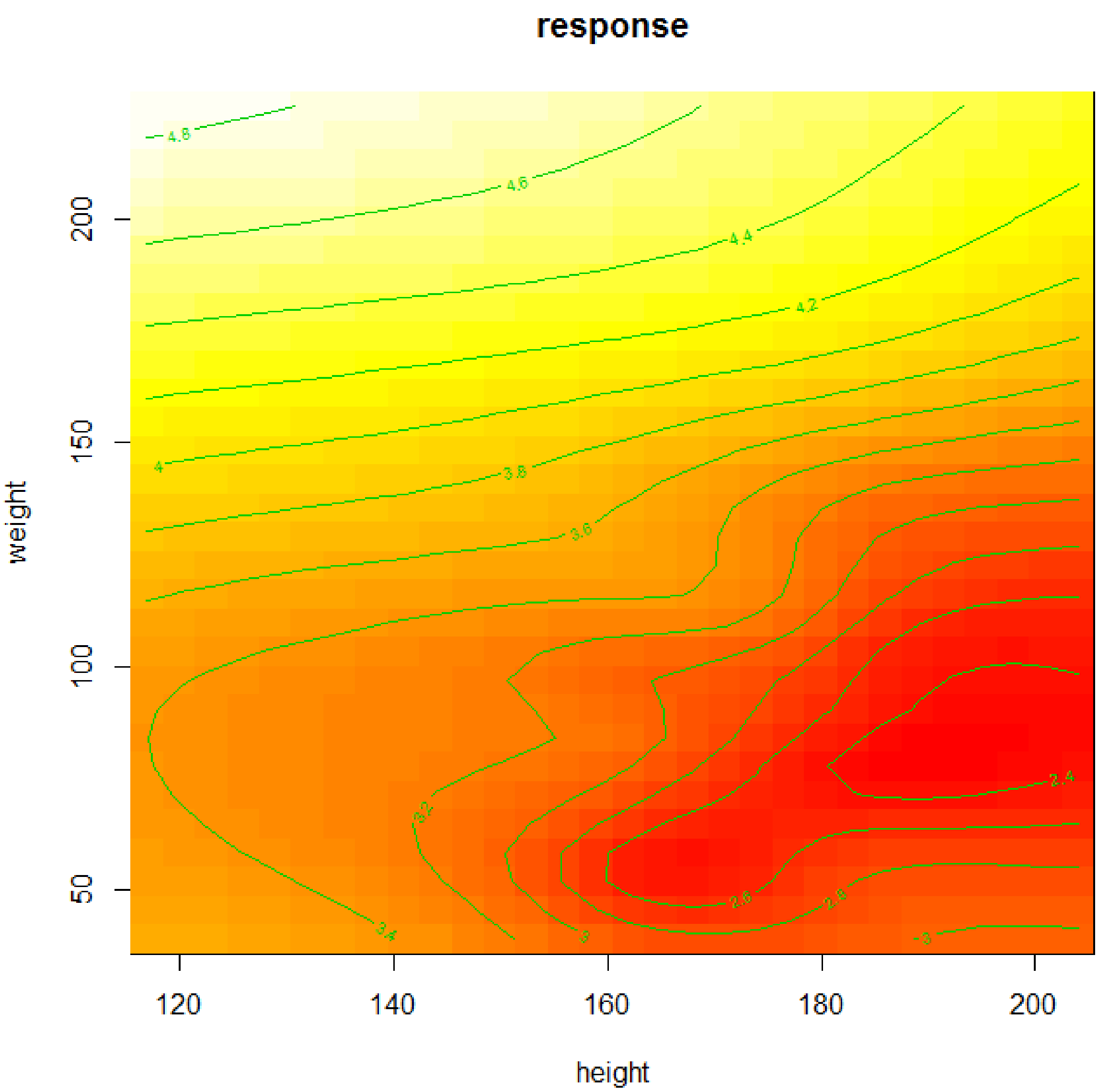


Fig. 3. **Weight and height effects on health, measured by current subjective status of health – women**

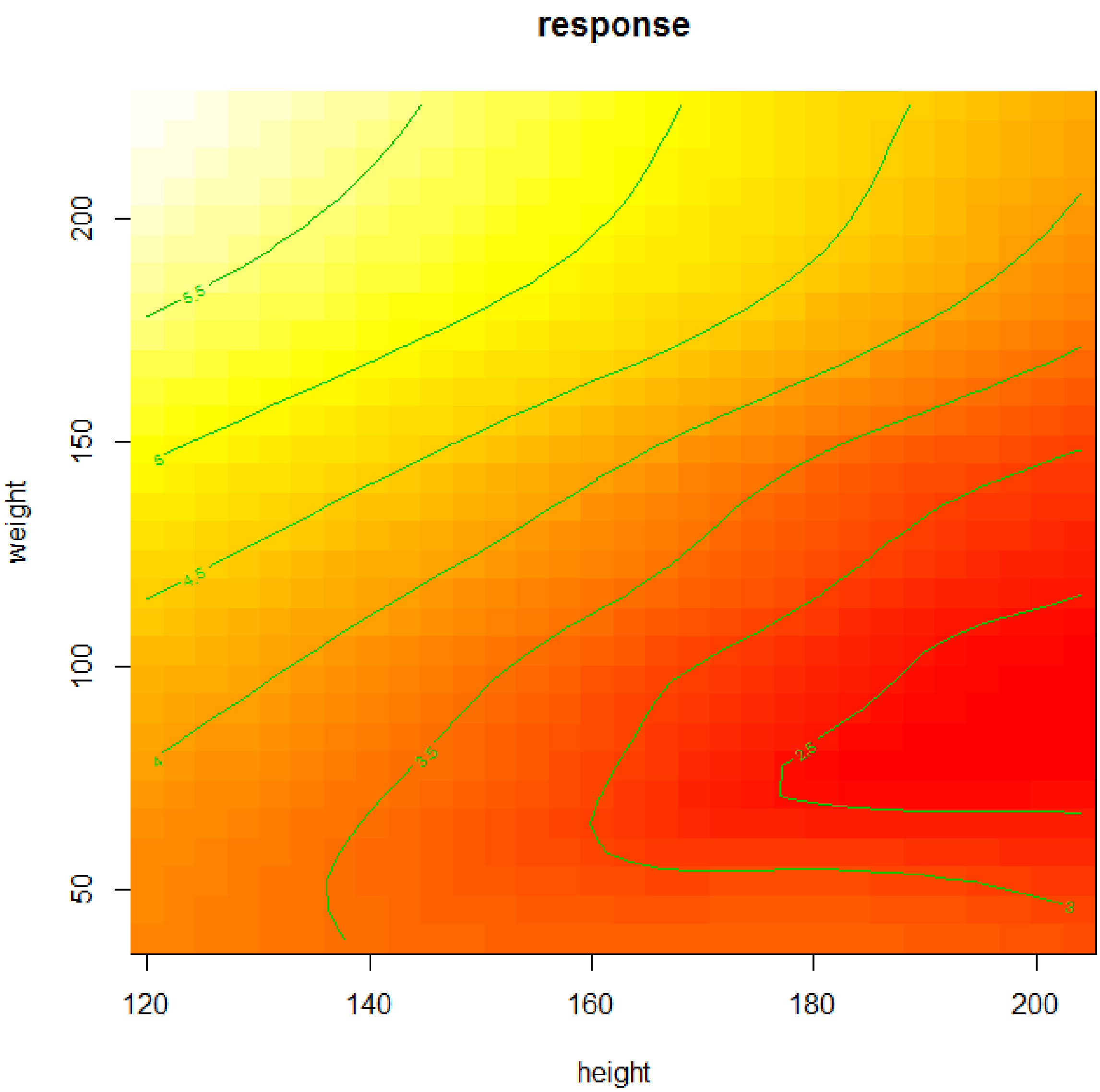


Fig. 4. **Weight and height effects on health, measured by current subjective status of health - men**

Table 1a: correlations of health indicators – women

	h1	h2	h3	h4	h5	h6	h7	h8
h1	1.0000							
h2	-0.7637*	1.0000						
h3	-0.5598*	0.5193*	1.0000					
h4	-0.5760*	0.5213*	0.7720*	1.0000				
h5	0.4088*	-0.4282*	-0.4140*	-0.4319*	1.0000			
h6	0.2250*	-0.2598*	-0.2241*	-0.1753*	0.1631*	1.0000		
h7	0.1001*	-0.0905*	-0.0477*	-0.0195	0.0484*	0.2617*	1.0000	
h8	-0.3369*	0.3434*	0.2895*	0.3627*	-0.4715*	-0.0682*	-0.0156	1.0000

Table 1b: correlations of health indicators – men

	h1	h2	h3	h4	h5	h6	h7	h8
h1	1.0000							
h2	-0.7379*	1.0000						
h3	-0.4634*	0.4354*	1.0000					
h4	-0.4815*	0.4852*	0.7014*	1.0000				
h5	0.4274*	-0.3920*	-0.4048*	-0.3994*	1.0000			
h6	0.2183*	-0.2340*	-0.1689*	-0.2149*	0.0888*	1.0000		
h7	0.1527*	-0.1390*	-0.0526*	-0.0437*	0.0331*	0.2018*	1.0000	
h8	-0.2975*	0.2954*	0.3293*	0.3454*	-0.4132*	-0.1224*	-0.0318*	1.0000

Notes: * p<=0.05; h1 – current health (=1 if very good, … , = 5 if bad); h2 – health satisfaction (=0 if completely dissatisfied, … , =10 if completely satisfied); h3 – problems at climbing several flights of stairs on foot due to the own health status (=1 if greatly, =2 if somewhat, =3 if not at all); h4 – problems at lifting something heavy or doing something requiring physical mobility (=1 if greatly, =2 if somewhat, =3 if not at all) ; h5 – suffering from any conditions or illnesses for at least one year or chronically (=0 if no, =1 if yes); h6 – total number of nights spent to the hospital last year ; h7 – number of days unable to work last year due to illness; h8 - no chronical disease. Source: SOEP 2012/2013.

Table 2: t tests with unequal variances of weight indicators by gender

Indicator	mean women	mean men	t-test	prob value
BMI	26.183	27.473	-18.94	0.0000
Underweight	0.0143	0.0019	9.52	0.0000
Normal weight	0.4641	0.3042	22.37	0.0000
Overweight	0.3236	0.4662	-19.68	0.0000
Obesity I	0.1293	0.1744	-8.39	0.0000
Obesity II	0.0686	0.0532	4.32	0.0000

Source: SOEP 2012.

Table 3: Body mass index distribution in percent among diseased and healthy people in Germany and the United States

	Underweight	normal weight	overweight	obese class I	obese class II
Germany					
BMI group	<18.5	18.8-<25	25-<30	30-<40	>=40
A. German Socio-Economic Panel 2004-2012; age>=18					
All	1.4	41.7	38.0	14.3	4.5
Health: not good	1.0	34.6	40.1	17.7	6.6
Health: good	1.9	49.4	35.7	10.7	2.3
B. Microcensus 2013; age>=18					
All	2.0	45.5	36.7	14.7	1.0
Diseased	2.3	39.5	36.5	19.7	2.0
Healthy	1.9	46.7	36.8	13.7	0.8
United States					
BMI group	<18.5	18.8-<25	25-<30	30-<35	>=35
C. NHANES 2005-2012; age>=18, metabolic status					
Unhealthy	0,9	18,0	33,2	38,3	9,6
Healthy	3,1	44,8	33,1	17,0	2,0
D. NHANES 2005-2010; weighed, white men, age 50-64					
All	1.2	17.8	42.8	24.4	13.8

Sources: Statistisches Bundesamt (2014), Wagner et al. (2007), Costa (2015) and Tomiyama et al. (2016).

Table 4: Regressions and ordered probit estimates between health and weight

Method →	OLS			ordered probit		
Demographic group →	all	women	men	all	women	men
BMI	0.033***	0.096***	0.024*			
	(0.00)	(0.01)	(0.01)			
BMI^2 /1000		-0.836***	0.293			
		(0.16)	(0.18)			
Underweight				-0.187***	-0.535***	-0.195
				(0.05)	(0.06)	(0.11)
Normal weight				-0.163***	-0.353***	-0.231***
				(0.01)	(0.02)	(0.02)
Obesity I				0.224***	0.214***	0.218***
				(0.02)	(0.03)	(0.02)
Obesity II				0.558***	0.430***	0.544***
				(0.03)	(0.04)	(0.04)
Constant	0.944***	0.799***	1.743***			
	(0.04)	(0.13)	(0.16)			
r^2	0.147	0.060	0.034			
N	32255	17300	15335	32255	17300	15335

Notes: * p<0.05, ** p<0.01, *** p<0.001; standard errors in parentheses. Control variables in columns (1) and (4) are gender, age and schooling. In columns (4)-(6) overweight people are the base group. Source: SOEP 2004, 2006, 2008, 2010 and 2012.

Table 5: Random effects (RE) panel estimates of health

	RE			RE-ordered probit	
	all	women	men	women	men
BMI	0.043**	0.001	-0.090**		
	(0.01)	(0.03)	(0.04)		
BMI² /1000		0.733	2.063***		
		(0.61)	(0.71)		
Underweight				-0.530	-0.625
				(0.29)	(0.67)
Normal weight				-0.438***	-0.074
				(0.09)	(0.09)
Obesity I				0.137	0.285*
				(0.13)	(0.11)
Obesity II				0.980***	0.825***
				(0.20)	(0.19)
Height				-0.248	-0.835***
				(0.27)	(0.22)
Height²				0.001	0.002***
				(0.00)	(0.00)
Age	0.010	0.010***	0.019***	0.020***	0.040***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Schooling	-0.017	-0.018	-0.024	-0.040	-0.059
	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)
Gross wage/10000	-0.125	-0.130	-0.176**	-0.227	-0.329*

	(0.14	(0.14)	(0.00)	(0.26)	(0.14)
Desired-actual WT/1000	0.394	0.390*	0.426**	0.575	0.964**
	(0.23)	(0.23)	(0.18)	(0.43)	(0.37)
Number of siblings	0.028	0.028*	0.008	0.052	0.008
	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)
Treiman score father /100	-0.462*	-0.464**	0.008	-1.047**	-0.077
	(0.23)	(0.23)	(0.22)	(0.42)	(0.42)
D2004	-0.121	-0.123*	-0.083	-0.208*	-0.186
	(0.05)	(0.05)	(0.05)	(0.10)	(0.10)
D2006	-0.111	-0.112**	-0.103**	-0.227**	-0.234**
	(0.04)	(0.04)	(0.04)	(0.08)	(0.08)
D2008	-0.017	-0.017	-0.089*	-0.040	-0.189*
	(0.04)	(0.04)	(0.04)	(0.08)	(0.08)
D2010	-0.033	-0.033	0.015	-0.057	0.013
	(0.04)	(0.04)	(0.04)	(0.08)	(0.08)
Constant	0.993**	1.547**	2.600***		
	(0.23)	(0.51)	(0.62)		
N	2604	2604	2544	2604	2544
BREUSCH-PAGAN	1072***	1063***	710***	980***	737***

Notes: * p<0.05, ** p<0.01, *** p<0.001, further control variables: 57 industries. The Breusch-Pagan test on individual effects is based on random effects estimates. If the test statistic exceeds the critical value of the $\chi^2(1)$distribution, H_0: (no individual effects)is rejected. In columns 3 and 4 overweight people are the base group. Standard errors are in parentheses. Source: SOEP 2004, 2006, 2008, 2010 and 2012.

Table 6: Lewbel's instrumental variable estimates of health

	women	men	women	men
BMI <=10 percentile	-0.265	0.140		
	(-1.67)	(1.01)		
BMI >=90 percentile	0.383*	0.453***		
	(3.02)	(3.54)		
Underweight			-0.130	-0.255
			(-0.87)	(-1.18)
Obesity II			0.563***	0.509***
			(6.47)	(6.32)
Schooling	-0.042*	-0.026*	-0.048**	-0.030*
	(-3.06)	(-2.03)	(3.38)	(-2.32)
Height	0.015***	-0.368***	0.014***	-0.418***
	(5.19)	(-4.46)	(4.77)	(-4.99)
Height^2		0.001***		0.001***
		(4.44)		(5.06)
Age	0.012***	0.024***	0.011***	0.022***
	(6.60)	(15.09)	(6.30)	(14.48)
Gross wage/10000	0.010	-0.225***	0.009	-0.211**
	(0.89)	(-3.85)	(0.55)	(-3.44)
|Desired-actual working hours|/1000	0.085	0.436*	0.044	0.377*
	(0.35)	(2.33)	(0.41)	(2.13)
Number of siblings	0.032*	0.003	0.030*	-0.003
	(2.87)	(0.35)	(2.63)	(-0.35)

Treiman score father	-0.005**	-0.001	-0.007***	-0.001
	(-3.46)	(-1.04)	(-4.97)	(-0.21)
Constant	-0.374	34.448***	-0.167	39.453***
	(-0.76)	(4.66)	(-0.33)	(5.30)
N	2495	2455	2495	2455
EXO	22.23***	16.30**	31.70***	4.42***
STOCK-YOGO	21.54	23.11	0.95	0.02
Critical value (10% bias)	10.96	11.00	7.03	7.03

Notes: * p<0.05, ** p<0.01, *** p<0.001, z statistics in parentheses; EXO-endogeneity test following the Durbin-Wu-Hausman test (H_0: exogeneity); STOCK-YOGO-weak instrument tests (H_0: weak instruments), the critical values are based on the assumption that we are willing to tolerate distortion for a 5% Wald test based on the 2SLS estimator, so that the true size can be at most 10%. We reject the null hypothesis if the STOCK-YOGO test statistic exceeds the critical value (Cameron and Trivedi 2009, p.193). BMI > 10 percentile & BMI< 90 percentile is the base group in columns 1 and 2. Normal weight, overweight and adipose I people are the base group in columns 3 and 4. There, 5 year dummies and 59 industries are further control variables. In columns 1 and 2 Lewbel's instrumental variables estimator is used, where additionally two exogenous instruments are incorporated (a dummy whether the individual had conflicts with his/her father during the adolescence, the grade in mathematics). The latter are also used in the estimates of columns 3 and 4. Source: SOEP 2004, 2006, 2008, 2010 and 2012.

Table 7: Resilience influences of underweight and adipose people against bad health

weight group →	under/normal weight		obesity I		obesity II	
demographic group →	women	men	women	men	women	men
Smoker	0.146***	0.519***	-0.364***	-0.238**	5.990***	-0.572**
	(2.59)	(7.38)	(-3.06)	(-2.41)	(4.54)	(-2.12)
Healthy diet	0.150***	0.066*	-0.112	0.0370	-2.790***	-0.103
	(4.45)	(1.78)	(-1.54)	(0.60)	(-5.92)	(-0.55)
Sleep duration	-1.080***	-1.235***	1.771***	2.388***	-27.485***	13.660***
	(-5.96)	(-3.94)	(3.41)	(5.49)	(-7.57)	(6.62)
Sleep duration²	0.067***	0.092***	-0.117***	-0.193***	2.111***	-0.953***
	(5.23)	(3.86)	(-3.22)	(-6.33)	(7.88)	(-6.67)
Musical activities	-0.087*	-0.579***	-0.377***	-0.123	-0.692	-1.487***
	(-1.80)	(-8.49)	(-3.18)	(-1.22)	(-1.16)	(-2.94)
Sporting activities	-0.030	-0.221***	-0.733***	-0.406***	6.543***	-0.786**
	(-0.61)	(-3.51)	(-5.79)	(-4.55)	(9.32)	(-2.33)
|Desired-actual| WT	-0.001***	0.001***	0.002**	0.003***	0.010**	0.026***
	(-3.59)	(3.21)	(2.48)	(4.83)	(2.27)	(6.21)
Schooling	-0.110***	-0.021	0.289***	-0.101***	0.486***	-0.182
	(-5.80)	(-0.96)	(7.07)	(-2.94)	(3.56)	(-0.48)
Public sector	0.117	-0.763***	1.652***	-0.977	4.939***	
	(0.83)	(-2.93)	(4.27)	(-0.93)	(3.46)	
Undenominational	-0.825***	0.037	-0.479***	-0.217	-6.367***	2.784***
	(-11.33)	(0.37)	(-2.10)	(-1.62)	(-6.42)	(7.08)
Weight_cv	3.674***	-1.238	-3.621*	0.042	-37.639***	108.649***

	(4.87)	(-0.86)	(-1.80)	(0.02)	(-5.28)	(7.48)
Weight growth	-0.849***	-2.430***	0.812	5.175***	-1.051	-24.944***
	(-2.91)	(-5.00)	(1.14)	(6.65)	(-0.53)	(-6.28)
N	2501	1493	568	798	247	247

Notes: * p<0.05, ** p<0.01, *** p<0.001, ordered probit estimates, z statistics in parentheses; cv – coefficient of variation, WT-working time in hours. A separate estimation of underweight people does not converge, too few observations. Source: SOEP 2012.

Table 8: Factor loadings of a six component model after orthogonal varimax rotation

	comp 1	comp 2	comp 3	comp 4	comp 5	comp 6
Openness	$\boxed{0.5202}$	0.1537	-0.0314	0.0736	0.0723	-0.0824
Extraversion	$\boxed{0.5058}$	-0.0906	-0.0030	-0.0243	-0.0711	0.0976
Conscientiousness	$\boxed{0.3956}$	0.1884	0.2582	-0.0576	0.0473	-0.1401
Agreeableness	$\boxed{0.4198}$	-0.2325	-0.0930	0.0310	-0.0002	0.1404
Neuroticism	0.2321	$\boxed{-0.3955}$	-0.1608	-0.0669	0.0354	0.1381
Smoker	-0.0231	-0.0089	$\boxed{0.6077}$	-0.0235	-0.0309	0.0033
Health diet	-0.2277	-0.1129	$\boxed{0.3757}$	0.0948	0.1176	0.2073
Sleep duration	-0.1089	0.1461	$\boxed{-0.3117}$	-0.2787	0.1340	-0.1026
Musical activities	0.0078	0.0354	0.0029	$\boxed{0.5739}$	0.0421	-0.0258
Sporting activities	-0.0459	0.0656	-0.1138	$\boxed{0.3369}$	-0.0287	$\boxed{0.4422}$
|Desired-actual| WT	0.0993	0.2116	$\boxed{0.4168}$	-0.0818	0.0362	-0.0069
Schooling	0.0128	0.2195	-0.1092	$\boxed{0.4697}$	0.0887	0.0159
Public sector	0.0271	-0.0009	0.0780	-0.1055	0.0587	$\boxed{0.6679}$
Undenominational	0.0105	-0.2527	0.0869	$\boxed{0.4626}$	-0.0817	-0.2244
Self-confidence	0.0178	$\boxed{0.4761}$	-0.2217	0.0478	0.0106	-0.0838
Gross wage	0.0883	$\boxed{0.5389}$	0.0887	-0.0058	-0.0747	0.1739
Weight_cv	0.0364	-0.0866	0.1178	0.0199	$\boxed{0.6379}$	-0.2995
Weight growth	-0.0162	0.0334	-0.0840	0.0009	$\boxed{0.7204}$	0.2278

Notes: Factor loadings larger than 0.3 determine the interpretation of the components; cv-coefficient of variation, WT-working time. Source: SOEP 2012.

Table 9: Resilience influences of people with different low and high weight (BMI) against bad health including Big5 of personality using principal component analysis – six component model

	BMI <= lower quartile		BMI >= upper quartile	
	women	men	women	men
Component 1 – OECA	-0.085***	-0.147***	-0.157***	0.036*
	(-4.07)	(-5.76)	(-5.40)	(1.69)
Component 2 – success & confidence	-0.130***	0.005	-0.114***	-0.164***
	(-6.70)	(0.15)	(-3.40)	(-6.73)
Component 3 – health behavior	0.125***	0.048	0.169***	0.186***
	(5.89)	(1.60)	(4.58)	(6.36)
Component 4 – early influences	-0.182***	-0.120***	0.121***	-0.030
	(-9.31)	(-3.46)	(3.45)	(-0.92)
Component 5 – weight variability	-0.104***	-0.255***	0.015	0.141***
	(-4.08)	(-6.62)	(0.61)	(4.82)
Component 6 – residual	0.017	-0.018	0.039	0.106**
	(0.95)	(-0.46)	(1.32)	(2.38)
N	2152	989	828	1099

Notes: For the variables of the principal components and the factor loadings see Table 8, * p<0.10, ** p<0.05, *** p<0.01, ordered probit estimates, z statistics in parentheses. Source: SOEP 2012.

Appendix

Table A1: Descriptive statistics of individual characteristics

Variable	Obs.	Mean	Std. Dev.	Min	Max
year	68,819	2009.119	2.790888	2004	2013
health indicators					
health (h1)	68,782	2.672618	.9676437	1	5
health satisfaction (h2)	66,745	6.658282	2.156527	0	10
healthy (1 if (very) good)	68,817	.4694189	.4990675	0	1
no. of absent days (h7)	68,819	4.258359	19.71382	0	365
healthy diet	33,224	2.383518	.7650056	1	4
smoker	33,265	.3421314	.4744305	0	1
sleep duration	18,313	6.995413	1.276908	1	12
weight indicators					
weight	32,762	77.33151	16.13296	32	225
height	33,173	171.084	9.234607	117	205
BMI	32,647	26.31632	4.64416	14.4525	69.8554
BMI_class	32,647	2.787931	.868037	1	5
underweight	32,647	.0143045	.1187449	0	1
normal weight	32,647	.4170368	.4930766	0	1
overweight	32,647	.38028	.485463	0	1
obesity I	32,647	.1430453	.3501244	0	1
obesity II	32,647	.0452722	.2079036	0	1
BMIq<=20.3_women	32,647	.0661623	.2485694	0	1

BMIq>20.3-22.1_women	32,647	.1037461	.3049356	0	1
BMIq>22.1-24.8_women	32,647	.2392869	.4266547	0	1
BMIq>24.8-28.4_women	32,647	.3117285	.4632067	0	1
BMIq>28.4-32.1_women	32,647	.1757282	.3805946	0	1
BMIq>32.1_women	32,647	.1031948	.3042178	0	1
BMIq<=22.4_men	32,647	.1905535	.3927437	0	1
BMIq>22.4-24.2_men	32,647	.1569516	.3637607	0	1
BMIq>24.2-26.5_men	32,647	.2247067	.4173954	0	1
BMIq>26.5-29.3_men	32,647	.1983643	.3987741	0	1
BMIq>29.3-32.3_men	32,647	.1323246	.3388485	0	1
BMIq>32.3_men	32,647	.0969461	.2958889	0	1
weight_cv	18,080	.0392647	.0307621	0	.7145
weight growth	17,897	.0152379	.0902887	-.5584416	.3925
Socio-economic characteristics and schooling					
German	68,819	.96469	.1845636	0	1
male	68,819	.4625903	.4986022	0	1
age	68,819	54.72436	16.32878	17	103
schooling	68,103	2.384036	1.438804	1	7
Working characteristics					
gross wage	36,017	2778.382	2664.009	0	70000
|desired-actual| WT	31,036	64.99629	77.17191	0	900
Characteristics as adolescents and adults					
musical activities	68,198	.3145987	.4643592	0	1

sporting activities	68,819	.5535681	.4971258	0	1
number of of siblings	44,996	1.565606	1.114286	0	8
self-confidence	68,509	2.190836	.7166314	1	3
Parents : schooling and socio-economic status (Treiman score)					
schooling_mother	66,271	1.554903	1.278308	0	6
Treiman score_father	58,032	41.16718	12.33288	13	78
Big 5					
openness	18,090	13.42941	3.664901	3	21
extraversion	18,276	14.99141	2.299392	5	21
conscientiousness	18,131	14.23953	1.967002	3	21
agreeableness	18,292	14.30746	2.207225	6	21
neuroticism	18,255	12.28129	2.609186	3	21

Notes: Weight and height and in consequence BMI are collected in 2004, 2006, 2008, 2010 and 2012. The BIG 5 variables are only determined in 2013.The weight growth rate is calculated from 2004 to 2012. Sleep duration is surveyed on 2012. The upper bound of BMIq… are the 10, 25, 50, 75, 90 and 100 percentiles of the body mass index split by gender. The subdivision into underweight, normal weight overweight, obesity 1 and obesity 2 follows Costa (2015). Weight_cv measures the weight's coefficient of variation. Music and sport are dummies that indicate activities during adolescence.

Table A2: Descriptive statistics of health indicators

Variable	obs	mean	std. dev.	min	max
h1	18,328	2.8134	0.9384	1	5
h2	18,329	6.4207	2.1295	0	10
h3	18,311	2.3616	0.7291	1	3
h4	18,311	2.2566	0.7447	1	3
h5	18,330	0.5002	0.5000	0	1
h6	18,330	2.1395	9.2931	0	182
h7	18,330	5.1210	21.383	0	365
h8	18,323	0.2723	0.4452	0	1

Notes: h1 – current health (=1 if very good, … , = 5 if bad); h2 – health satisfaction (=0 if completely dissatisfied, … , =10 if completely satisfied); h3 – problems at climbing several flights of stairs on foot due to the own health status (=1 if greatly, =2 if somewhat, =3 if not at all); h4 – problems at lifting something heavy or doing something requiring physical mobility (=1 if greatly, =2 if somewhat, =3 if not at all) ; h5 – suffering from any conditions or illnesses for at least one year or chronically (=0 if no, =1 if yes); h6 – total number of nights spent to the hospital last year ; h7 – number of days unable to work last year due to illness; h8 – no disease. Source: SOEP 2012/2013.