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WEIGHT STATUS IN ADOLESCENCE IS ASSOCIATED WITH LATER LIFE FUNCTIONAL LIMITATIONS

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Abstract

Objectives—This study examines the relationship between weight status in adolescence and later life functional limitations.

Methods—We use the Wisconsin Longitudinal Study to characterize the relationship between standardized relative body mass ascertained from high school photograph portraits in 1957 and self-reported functional limitations in 2004.

Results—Compared to individuals with normal body mass, those who were overweight in high school had poorer later life physical function, with observed gender differences. Women who were underweight in adolescence had better functioning in older adulthood than their normal weight counterpart. This relationship, however, was not found among men.

Conclusions—These findings underscore the long-term consequences of being overweight in adolescence on the disadvantages conferred in late life functional limitations.

Keywords

physical function; overweight; adolescence; late life health; functional limitations; lifecourse

INTRODUCTION

Studies of health in late life have shifted from examining older adult conditions to focusing on circumstances in early life. Investigating the link between conditions in childhood (and adolescence) and later life outcomes encompasses a lifecourse approach, which posits that early experiences have independent effects on later life outcomes via a variety of mechanisms (Kuh & Ben-Shlomo, 2004). A growing body of the lifecourse literature suggests that early life health is strongly associated with a broad range of health outcomes in later life. An adverse environment in utero, at or around birth, and in childhood has significant effects on the subsequent risk of cardiovascular disease, diabetes, hypertension, and mortality in adulthood. Maternal smoking during pregnancy, impaired fetal development, and birth month are also linked to increased risk of adult hypertension, coronary heart disease (CHD), and shorter life expectancy (Cruick-Shank et al., 2005; Doblhammer & Vaupel, 2001). From birth through infancy, low birth weight, lack of breastfeeding, and high salt consumption during infancy are risk factors for CHD, hypertension, and diabetes in adulthood, as well as reduced longevity (Barker, 1998; Blane et al., 1996; Cruick-shank et al., 2005; Huxley, Shiel, & Law, 2000; Lawlor & Smith, 2005).

A particularly salient finding, given the increase in worldwide obesity among children (Ebbeling, Pawlak, & Ludwig, 2002), is the link between childhood obesity and cardiovascular disease risk factors and outcomes. Some of the earliest work on the long-term consequences of weight status examines the relationship between birth weight on heart disease in later life (Barker et al., 1989; Frankel et al., 1996; Leon et al., 1998; Rich-Edwards et al., 1997; Stein et al., 1996). Low birth weight is associated with increased late life coronary heart disease (CHD), with an additional increase in risk observed among children with low weight at 1 year (Barker et al., 1989). After age 1, however, rapid increases in weight gain and body mass index (BMI) are associated with an increased risk in adult CHD (Eriksson et al., 1999, 2001).

The long-term consequences of overweight in children is also characterized by early maturation, as determined by peak height velocity, bone age, age of menarche for girls, and higher fatness in adulthood (Garn et al., 1986; Van Lenthe, Kemper, & van Mecehelen, 1996). The adverse consequences of childhood obesity and later life health extend to overweight in adolescence. For instance, the relationship between obesity in childhood and adolescence is associated with greater risk of dyslipidemia, hypertension, arterial stiffness, elevated levels of inflammation, hyperinsulinaemia, tendency for blood clotting, and cardiovascular mortality in adulthood (Blacer et al., 1999; Field et al., 1999; Figueroa-Munoz, Chinn, & Rona, 2001; Freedman, Dietz, Srinivasan, & Berenson, 1999; Gunnell, Frankel, Nanchahal, Peters, & Smith, 1998; Juonala et al., 2005; Redline et al. 1999; Reybrouck, Mertens, Schepers, Vinckx, & Gewilling, 1997; Wright, Parker, Lamont, & Craft, 2001).

The substantial literature on early life obesity and later life health largely focuses on adulthood cardiovascular health as the outcome. However, little is known about the later life functional consequences of early life weight status. Must and colleagues (1992) report that overweight female adolescents have a greater risk of arthritis in adulthood. No studies, to our knowledge, investigate the link between early life obesity and physical function in later life. Evidence for such associations exists given that the long-term consequences of general indicators of childhood health and childhood circumstances are linked to trajectories of functional health in later life (Haas, 2008). Guralnik and colleagues (2006) find that lower childhood socioeconomic status, as indicated by father's occupation, is associated with low function in midlife within the British 1946 birth cohort. In a Latin American and Caribbean population, retrospective reports of poor early life conditions (SES and health status before age 15) are associated with disability in later life (Monteverde, Noronha, & Palloni, 2009).

Our study aims to investigate the longitudinal association between weight status in adolescence and functional health approximately forty-seven years later. To accomplish this, we examine the links between a novel indicator of adolescent weight status and physical function in later life using the Wisconsin Longitudinal Study (WLS), a prospective cohort study following high school graduates from Wisconsin schools in 1967. The current study contributes to the literature in two unique ways. First, the use of high school photographs to determine weight status in adolescence in WLS provides a unique opportunity to estimate adolescent body mass and its relationship to adult outcomes at advanced ages. Child and adolescent overweight and obesity emerged as a major health concern after the 1980s, and

several longitudinal studies established prior to this time do not include questions regarding body weight prior to adulthood. The strength of these measures is that perceptions of overweight derived from photographs are representative of childhood conditions and are not retrospective self-reports of childhood body weight. Given this, they are not influenced by potential biases in respondents' recall or confounded by current and previous health. The WLS high school photograph-based body mass measures have previously been used to predict chronic health conditions, mortality, and labor market outcomes, and are proven to be a reliable measure of body weight (Reither, Hauser, & Swallen, 2009; Glass, Haas, & Reither, 2010). Second, the availability of two indices of functional health in late life allows for the examination of the long-term functional consequences of weight status in adolescence. Taken together, this study illustrates the potential influence of adolescent weight on functional health, which is of particular importance given that declines in functioning and disability have been associated with loss of independence, difficulty performing daily activities, and severity of comorbidities among older adults.

METHODS

Data

The WLS is a longitudinal study that follows 10,317 Wisconsin public, private, and parochial high school graduates in 1957 (Sewell, Hauser, Springer, & Hauser, 2004). Subsequent waves of WLS were conducted in 1964, 1975, 1993, and 2004 to collect data on a wide variety of sociodemographic, health, and behavioral factors. Although WLS is not nationally representative, its study participants resemble more than 2/3 of Americans of the same age (Hauser, 2005). In the most recent survey (2004), from which outcome measures are drawn, respondents are approximately 65 years of age. The WLS presents a unique opportunity to examine early life factors in addition to health and wellbeing in late adulthood.

Measures

Standardized Relative Body Mass from Photographs—Yearbook photos of the 1957 graduates were collected in 2000. Information on height and weight was not collected as part of WLS until the 1993 wave. To estimate body mass in adolescence, yearbook photos of the study respondents were assessed based on an eleven point scale (Reither, Hauser, & Swallen, 2009). Six coders scored all yearbook photos, and scores were combined to create a standardized relative body mass index (SRBMI), where the values represent standard deviation differences from the mean scale value. Initially, 3,027 randomly selected photographs were coded in January of 2005. In 2008, an additional 5,592 cases were coded and added to the data. The SRBMI scale has demonstrated inter-rater reliability ($\alpha=.91$) for both genders and is highly correlated with body mass among adults aged 53 and 54 (Reither, Hauser, & Swallen, 2009).

We construct four SRBMI categories similar to that of previous research using high school body mass to predict later adult outcomes (Glass, Haas, & Reither, 2010). The categories are as follows: underweight (SRBMI ≤ -1), normal weight ($-1 < \text{SRBMI} < 0$), risk of overweight ($0 < \text{SRBMI} < 1$), and overweight (SRBMI ≥ 1). Normal weight is the reference group for all

analyses. These weight categories do not perfectly correspond to the standard, currently used BMI categories, but were employed here to be consistent with that prior studies using this same SRBMI variable (Glass, Haas, & Reither, 2010; Reither, Hauser, & Swallen, 2009).

Physical Functioning—Several self-reported measures of physical functioning are available for the 2004 wave. First, we use a measure of mobility through the Health Utility Index 3 (HUI3) Scale Ambulation score. This score rates ambulation ability on a scale between 0 and 1, where 1 represents perfect health utility and 0 represents death. There is a six-point scale of utility (Feeny et al., 2002), which includes the following factors: (1) able to walk around the neighborhood without difficulty, and without walking equipment (utility=1.00); (2) able to walk around the neighborhood with difficulty; but does not require walking equipment or the help of another person (utility=.83); (3) able to walk around the neighborhood with walking equipment, but without the help of another person (utility=.67); (4) able to walk only short distances with walking equipment and requires a wheelchair to get around the neighborhood (utility=.36); (5) unable to walk alone, even with walking equipment; able to walk short distances with the help of another person; and requires a wheelchair to get around the neighborhood (utility=.16); and (6) unable to walk at all (utility=0).

We also create a composite measure of physical limitations based on seven questions pertaining to whether the respondent is able to complete the following activities: climb stairs, lift a 25 pound weight, push or pull a heavy object (e.g., a chair), stand for 1 hour, sit for 1 hour, kneel down, and reach above one's head. The number of tasks that the participant is unable to complete is summed to generate a scale ranging from 0 (no limitations) to 7 (extremely limited).

Control Variables—In order to disentangle the influence of high school body weight and adult body weight, we controlled for adult body mass index (BMI) as measured in the 1993 WLS survey wave when the study participants were approximately 55 years of age. Adult BMI is categorized as follows: normal weight is BMI 18.5–24.9 kg/m², overweight is BMI 25–29.9 kg/m², obese is BMI > 30 kg/m², and underweight is BMI < 18.5 kg/m². The underweight category is only included for females, as there are only 4 males in the final sample who are categorized as underweight.

Several control variables from the respondent's adolescence are used. We include the log of family income from 1957 and highest education of the head of household in 1957 (in most cases, this pertains to the fathers' education) as sociodemographic controls. Due to the low levels of educational attainment in 1957, four education categories are created: less than 8th grade, grade 8 to 11, high school diploma (12 years), and some college (13 or more years). Both income and education are included because they each serve as a proxy for different aspects of SES. For instance, in 1957, individuals with low levels of education had better labor market opportunities than in recent decades. A retrospective report of the respondent's health as a child is also included as a dichotomous variable where excellent/very good health translates to good health and good/fair/poor health translates to poor health (Smith, 2009).

Data Analysis

We calculate mean scores for both the HUI3 and Limitations Scale scores, as well as sample percentages for each factor included in the Limitations Scale by SRBMI category for both females and males. Gender stratified, ordinary least squares (OLS) regression models are estimated for the continuous HUI3 and Limitations Scale outcomes. The Limitations Scale score is normally distributed, and the HUI3 score follows a normal distribution when transformed by its square root. For the ease of interpretation and because the results were robust to the alternate transformation specifications (available upon request), we present results from the non-transformed HUI3 score. Stata 11 SE is used to conduct all analyses.

RESULTS

Table 1 describes the analytic sample. The majority of the sample is either normal weight (43.0%) or overweight (35.9%). According to the SRBMI scale, approximately 10% of the sample was either underweight or overweight in adolescence. The distribution of highest education level for the head of household differs substantially from current education distributions. Most head of householders have less than a high school diploma and only 14.1% have attained some college education or more. The majority of participants indicate that their childhood health was very good or excellent (84.0%). Finally, there is a higher proportion of females (54.1%) compared to males (45.9%), which is commonly reported in older populations.

In Table 2 we present each measure of physical function by weight category for females in Panel 1 (top) and males in Panel 2 (bottom). Among females, there is a clear pattern that physical function in late adulthood steadily decreases with increasing body weight in adolescence. For most outcomes, women who were underweight in high school have the least risk of facing a functional limitation, followed in ascending order by normal weight, risk of overweight, and overweight women. The only exception is in the lack of ability to lift 25 pounds, as women who were at risk of overweight in high school are able to perform this task at the same level as underweight women (about 35% in both weight categories).

The influence of adolescent body weight on later adult functioning is not as clearly demarcated for males as it is for females. The second panel of Table 2 demonstrates this subtle pattern. There is one important distinction in physical functioning among males: underweight boys in high school do not experience the same benefits in functioning in later life that is clearly evident for women. While there is a disadvantage to being overweight as an adolescent for boys, we do not observe the body weight-based gradient in later functioning that girls experience. From these descriptive results, it appears that the consequences of high body mass during adolescence are much more pronounced for females than males.

In the multivariate OLS results in Table 3, we present OLS regression estimates of the HUI3 Ambulation Scale score for each body mass category compared to those of normal weight in high school for both women and men. A high HUI3 score indicates a better level of mobility in a range from 0 to 1. We estimate models that include other combinations of covariates, but only report on the fully adjusted models (Models 1 and 3) and models that examine the

mediating influence of adult BMI (Models 2 and 4). For females, in Model 1 there is no difference in the HUI3 score between those who were underweight, normal weight, and risk of overweight during adolescence. However, women who were overweight in high school had a significantly lower score than the normal weight group ($\beta = -.035$). Model 2 includes adult BMI measured about 10 years prior to the HUI score. The relationship between overweight in high school and reduced HUI3 scores in later life remains statistically significant even when controlling for adult BMI. Adult overweight, obesity, and underweight are all significant predictors of reduced ambulation scores. In both Models 1 and 2, poor child health significantly reduces the adult HUI3 score ($\beta = -.020$) compared to good childhood health.

For males, we observe the same pattern as seen for females in Model 3 (Table 3), except that relative to their normal weight counterparts, both those who were identified as being at risk of overweight ($\beta = -.013$) and those who were overweight ($\beta = -.017$) in high school are significantly disadvantaged in their adult HUI3 scores. Like females, these relationships are statistically significant when adult BMI is added in Model 4, though the association between adult BMI and HUI3 scores is much weaker for males than for females. There is a similar relationship between education and HUI3 scores in females, though higher education is only associated with mobility for males. Finally, child health does not impact the ambulation score for males.

Table 4 reports on the relationship between body weight in adolescence and the limitations score for both females and males, as well as for the entire sample. For this outcome, the limitations score ranges from 0 to 7, and higher scores represent more physical limitations in later adulthood. In Model 1, we find that being underweight during adolescence is associated with significantly less adult limitations for females ($\beta = -.282$), while those who were overweight have significantly more adult limitations than normal weight teens ($\beta = .574$). However, in Model 2 when adult BMI is added, these relationships between high school body weight and the limitations score are only marginally significant.

For males, we report a statistically significant association between risk of overweight in high school and more physical limitations in later life (Model 3; Table 4). However, when adult BMI is added in Model 4, the relationship between high school overweight and limitations is no longer statistically significant. Unlike the HUI3 scores presented in Table 3, Table 4 results indicate that none of the weight status categories are significant predictors of the physical limitations composite score for males. This suggests that among males adult BMI explains some of the relationship between being overweight in high school and having greater functional limitations in late life.

In supplementary analyses (available upon request), we estimate additional models with different parameterizations of our functioning variables. Logistic regression models are used to observe the odds ratios for having each of the seven physical limitations that comprised the limitations score and for a dichotomous measure of physical mobility that represented the first cutpoint of mobility in the HUI3 score. These results are similar to the findings presented here.

DISCUSSION

This study finds that adolescents with high body weight have poorer physical function in later life compared to teens with normal body weight. We also note gender differences in these relationships, with overweight teenage males having poorer later life physical function than their normal weight counterparts. This relationship, however, is not observed for adolescent women. Compared to normal weight adolescent women, their underweight counterparts have a lower physical limitations score in later life, but this was not reported among males. Moreover, we find a clear gradient in the relationship between adolescent body weight and later life physical function, with heavier teens exhibiting greater physical limitations at age 65.

Three frameworks underscore the links among early life conditions, adulthood exposures, and later life health (Berkman, 2009). First, the biological imprint framework views certain exposures or experiences in early life as permanently and irreversibly altering the functioning of tissues, organs, and physiological systems (Barker, 1997; Ben-Shlomo & Kuh, 2002). A second theory, the pathway framework, differs from the biological imprint framework in that it does not view childhood conditions as permanently leaving an imprint on adult health. Instead, early life circumstances initiate a trajectory of events that lead to adult exposures, which in turn contribute to later life health (Lundberg, 1993). Third, the cumulative framework combines both theories to include the direct and indirect effects of early life conditions on later life health.

We integrate the cumulative framework with our current findings given two reasons. First, being overweight in adolescence is likely to have lasting effects on later life health. This includes, for example, the stigma associated with being overweight or the greater incidence of sports injuries (e.g., knee injuries among heavier individuals). Second, childhood BMI is associated with adult overweight and adiposity (Freedman, Dietz, Srinivasan, & Berenson, 2005; Guo et al., 2000), which has, in turn, been associated with a number of health outcomes in late adulthood (Coakley et al., 1998; Engeland, Bjørge, Tverdal, & Sjøgaard, 2004).

The gender differences in the relationship between adolescent body mass index (BMI) and later life physical function is an interesting finding. Two distinct differences are observed. First, men who are in the risk of being overweight group had poorer functioning on the HUI3 score than normal weight men, but this was not observed for women. Second, underweight adolescent women have better functioning on the physical limitations score compared to their normal weight counterparts. We posit that these male-female differences may be due to social and/or biological factors. From a social perspective, it may be that heavy body mass during childhood and adolescence may be associated with greater stigma for females than males (Brownell, 1991; Garner & Garfinkel, 1980). Overweight young women are more depressed and have lower self-esteem than normal weight girls; however, overweight boys are similar to normal weight boys for these mental health outcomes (Erickson, Robinson, Haydel, & Killen, 2000; Strauss, 2000). As such, being underweight for girls may contribute to circumstances that are associated with better health outcomes like physical function. Conversely, given that boys are less subject to the stigma associated with

higher weight, being underweight in adolescence does not confer the same advantages for later life physical function in men as observed among women.

From a biological perspective, hormonal changes during the lifespan and in late life may be responsible for some of the observed gender differences. Estrogen loss with advancing age is common among women and is associated with the onset of menopause. Sowers and colleagues (2001) report greater functional limitations among natural and surgical postmenopausal women compared with premenopausal women. Moreover, this relationship remained after adjusting for age, race, body size, and economic stress.

We attempt to determine potential explanatory pathways that could explain gender differences by including adult BMI into our models. Among males, the relationship between overweight in high school and the physical limitations score in later life is no longer significant after controlling for adult BMI. The link between adult BMI and physical limitations in late life could be one factor explaining why the relationship between adolescent body weight and late life physical function is monotonic for females but not for males. Aside from the role of adult weight on understanding gender differences, adult weight is an important factor in the relationship between teen weight status and later life physical function. For the physical limitations score, the association between teen overweight and the physical limitations score is largely explained by weight status in adulthood. However, adult weight explains little of the relationship between teen overweight and the HUI ambulation score. This suggests that adult weight is linked to a range of functional limitations in later life but is less associated with limitations that solely involving lower limb tasks, such as walking.

This study has several strengths. First, the longitudinal nature of our data over a moderate period of time allows for us to utilize a lifecourse approach to determining the long-term effects of overweight in adolescence on physical function in later life. Second, we use a novel measure of body weight as an indicator of overweight in early life. The use of high school photographs, which illustrate characteristics of the face and neck, has been associated with body mass and central adiposity (i.e., fattiness) (Laakso, Matilainen, & Keinänen-Kiukaanniemi, 2002; Levine, Ray, & Jensen, 1998; Yu, Fujimoto, Urushibata, Matsuzawa, & Kubo, 2003). Finally, our use of multiple measures of physical function provides a broad spectrum of both upper and lower limb function in late life.

We note some limitations. First, we acknowledge that the use of photographs is not an objective indicator of body mass. Although coders used a relative body mass (RBM) scale (see Reither, Hauser, & Swallen, 2009 for additional details), individuals who ranked study participants as heavy on the RBM scale did not differentiate between lean mass (characterized by healthy, athletic body types) or fat mass (characterized by unhealthy, overweight body types). This limitation is not unique to the RBM scale: BMI does not provide information on lean or fat mass. Evidence suggests that face and neck characteristics (e.g., neck circumference and facial adipose tissue deposits) are indicative of general adiposity and that facial measures, such as bone structures, are associated with body mass (Yu et al., 2003). These studies suggest that the use of photographs may, in fact, be a better indicator of fat mass than BMI. Second, self-reported measures of physical function suffer

from greater bias relative to performance-based measures of physical functioning, especially for older adults who either do not engage in the task during their daily lives or have an inaccurate perception of their capabilities (Simonsick et al., 2008). Finally, WLS is not a nationally representative study and does not include minority groups. Additional studies that examine this relationship in a variety of populations will provide a more in-depth assessment of early life body mass on physical function.

This paper provides evidence that being overweight in early life confers some disadvantage on later life physical function for both men and women. Our findings are supported by reports of the adverse long-term effects of adolescent body mass on later life educational attainment and occupational standing (Glass, Hass, & Reither, 2010) as well as chronic health conditions and mortality (Reither, Hauser, & Swallen, 2009) – both of which use the same WLS dataset. From this growing body of evidence, it is hypothesized that these early life conditions likely influence other aspects of health and later life conditions. Thus, future studies would benefit from investigating the effects of adolescent weight status on other important health outcomes, such as mental health, in later life.

References

- Barker DJP, Osmond C, Winter PD, Margetts B, Simmonds SJ. Weight in infancy and death from ischaemic heart disease. *Lancet*. 1998; 2:577–580. [PubMed: 2570282]
- Barker DJP. Maternal nutrition, fetal nutrition, and disease in later life. *Nutrition*. 1997; 13:807–813. [PubMed: 9290095]
- Barker, DJP. *Mothers, Babies, and Health in Later Life*. London: Churchill Livingstone; 1998.
- Ben-Shlomo Y, Kuh D. A life course approach to chronic disease epidemiology: Conceptual models, empirical challenges and interdisciplinary perspectives. *International Epidemiological Association*. 2002; 31:285–293.
- Berkman LF. Social epidemiology: Social determinants of health in the United States: Are we losing ground? *Annual Review of Public Health*. 2009; 30:27–41.
- Blacer LJ, Liu GT, Forman S, Pu K, Volpe NJ, Galetta SL, Maguire MG. Idiopathic intracranial hypertension: relation of age and obesity in children. *Neurology*. 1999; 52:870–872. [PubMed: 10078746]
- Blane D, Hart CL, Davey Smith G, Gillis CT, Hole DJ, Hawthorne VM. Association of cardiovascular disease risk factors with socioeconomic position during childhood and during adulthood. *British Medical Journal*. 1996; 313:434–438.
- Brownell KD. Dieting and the search for the perfect body: where physiology and culture collide. *Behavior Therapy*. 1991; 22:1–12.
- Coakley EH, Kawachi I, Manson JE, Speizer FE, Willet WC, Colditz GA. Lower levels of physical functioning are associated with higher body weight among middle-aged and older women. *International Journal of Obesity*. 1998; 22:958–965. [PubMed: 9806310]
- Cruick-Shank JK, Mzayek F, Liu L, Kieltyka L, Sherwin R, Webber LS, Srinavassan SR, Berenson GS. Origins of the black/white difference in blood pressure: roles of birth weight, postnatal growth, early blood pressure, and adolescent body size. *Circulation*. 2005; 111:1932–1937. [PubMed: 15837946]
- Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. *Lancet*. 2002; 360:473–482. [PubMed: 12241736]
- Engeland A, Bjørge T, Tverdal A, Sjøgaard AJ. Obesity in adolescence and adulthood and the risk of adult mortality. *Epidemiology*. 2004; 15:79–85. [PubMed: 14712150]
- Erickson SJ, Robinson TN, Haydel F, Killen J. Are overweight children unhappy? Body mass index, depressive symptoms, and overweight concerns in elementary school children. *Archives of Pediatrics Adolescent Medicine*. 2000; 154:931–935. [PubMed: 10980798]

- Eriksson JG, Forsen T, Tuomilehto J, Winter PD, Osmond C, Barker DJP. Catch-up growth in childhood and death from coronary heart disease: longitudinal study. *British Medical Journal*. 1999; 318:427–431. [PubMed: 9974455]
- Eriksson JG, Forsén T, Tuomilehto J, Osmond C, Barker DJP. Early growth and coronary heart disease in later life: longitudinal study. *British Medical Journal*. 2001; 322:949–953. [PubMed: 11312225]
- Feeny D, Furlong W, Torrance GW, Goldsmith CH, Zhu Z, DePauw S, Denton M, Boyle M. Multiattributable and single-attribute utility functions for the health utilities index mark 3 system. *Medical Care*. 2002; 40:113–128. [PubMed: 11802084]
- Field AE, Camargo CA, Taylore CB, Berkey CS, Frazier AL, Gillman MW, Colditz GA. Overweight, weight concerns, and bulimic behaviors among girls and boys. *Journal of the American Academy of Child and Adolescent Psychiatry*. 1999; 38:754–760. [PubMed: 10361795]
- Figuerola-Munoz JI, Chinn S, Rona RJ. Association between obesity and asthma in 4–11 year old children in the UK. *Thorax*. 2001; 56:133–1337. [PubMed: 11209102]
- Frankel S, Elwood P, Swetnam P, Yarnell J, Davey Smith G. Birthweight, adult risk factors and incident coronary heart disease: the Caerphilly study. *Public Health*. 1996; 110:139–143. [PubMed: 8668758]
- Freedman DS, Dietz WH, Srinivasan SR, Berenson GS. The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart Study. *Pediatrics*. 1999; 103:1175–1182. [PubMed: 10353925]
- Freedman DS, Khan LK, Serdula MK, Dietz WH, Srinivasan SR, Berenson GS. The relation of childhood BMI to adult adiposity: The Bogalusa Heart Study. *Pediatrics*. 2005; 115:22–27. [PubMed: 15629977]
- Garn SM, LaVelle M, Rosenberg KR, Hawthorne VM. Maturational timing as a factor in female fatness and obesity. *American Journal of Clinical Nutrition*. 1986; 43:879–883. [PubMed: 3717062]
- Garner DM, Garfinkel PE. Cultural expectations of thinness in women. *Psychological Report*. 1980; 47:483–491.
- Glass CM, Haas SA, Reither EN. The skinny on success: Body mass, gender and occupational standing across the life course. *Social Forces*. 2010; 88:1777–806.
- Gunnell DJ, Frankel SJ, Nanchahal K, Peters TJ, Smith GD. Childhood obesity and adult cardiovascular mortality: a 57-y follow-up study based on the Boyd Orr cohort. *American Journal of Clinical Nutrition*. 1998; 67:1111–1118. [PubMed: 9625081]
- Guo SS, Huang C, Maynard LM, Demerath E, Towne B, Chumlea WC, Siervogel RM. Body mass index during childhood, adolescence and young adulthood in relation to adult overweight and adiposity: the Fels Longitudinal Study. *International Journal of Obesity*. 2000; 24:1658–1635.
- Guralnik JM, Butterworth S, Wadsworth MEJ, Kuh D. Childhood socioeconomic status predicts physical functioning a half century later. *Journals of Gerontology A Biological Sciences and Medical Sciences*. 2006; 61:694–701. [PubMed: 16870631]
- Hass S. Trajectories of functional health: The long arm of childhood health and socioeconomic factors. *Social Science and Medicine*. 2008; 66:849–861. [PubMed: 18158208]
- Hauser RM. Survey response in the long run: The Wisconsin Longitudinal Study. *Field Methods*. 2005; 17:3–29.
- Huxley RRR, Shiell AW, Law CM. The role of size at birth and postnatal catch-up growth in determining systolic blood pressure: a systematic review of the literature. *Journal of Hypertension*. 2000; 18:815–831. [PubMed: 10930178]
- Juonala M, Jarvisalo MJ, Maki-Torkko N, Kahonen M, Viikari JS, Raitakari OT. Risk factors identified in childhood and decreased carotid artery elasticity in adulthood. *Circulation*. 2005; 112:1486–1493. [PubMed: 16129802]
- Kuh, D.; Ben-Shlomo, Y. A life course approach to chronic disease epidemiology. New York: Oxford University Press; 2004.
- Laakso M, Matilainen V, Keinänen-Kiukaanniemi S. Association of neck circumference with insulin resistance-related factors. *International Journal of Obesity Related Metabolic Disorders*. 2002; 26:873–875. [PubMed: 12037660]

- Lawlor DA, Smith GD. Early life determinants of adult blood pressure. *Nephrology Hypertension*. 2005; 14:259–264.
- Leon DA, Lithell HO, Vagero D, Koupilova I, Moshen R, Berglund L, Lithell UB, McKeigue PM. Reduced fetal growth rate and increased risk of death from ischaemic heart disease: cohort study of 15 000 Swedish men and women born 1915–29. *British Medical Journal*. 1998; 317:241–245. [PubMed: 9677213]
- Levine JA, Ray A, Jensen MD. Relation between chubby cheeks and visceral fat. *New England Journal of Medicine*. 1998; 339:1946–1947. [PubMed: 9874618]
- Lundberg O. The impact of childhood living conditions on illness and mortality in adulthood. *Social Science and Medicine*. 1993; 36:1047–1052. [PubMed: 8475420]
- Monteverde M, Noronha K, Palloni A. Effect of early conditions on disability among the elderly in Latin America and the Caribbean. *Population Studies*. 2009; 63:21–35. [PubMed: 19184719]
- Must A, Jacques PF, Dallal GE, et al. Long-term morbidity and mortality of overweight adolescents; a follow-up of the Harvard Growth Study of 1922 to 1935. *New England Journal of Medicine*. 1992; 327:1350–1355. [PubMed: 1406836]
- Redline S, Tishler PV, Schluchter M, Aylor J, Clark K, Graham G. Risk factors for sleep-disordered breathing in children: associations with obesity, race, and respiratory problems. *American Journal of Respiratory Critical Care Medicine*. 1999; 159:1527–1532. [PubMed: 10228121]
- Reither EN, Hauser RM, Swallen KC. Predicting adult health and mortality from adolescent facial characteristics in yearbook photographs. *Demography*. 2009; 46:27–41. [PubMed: 19348107]
- Reybrouck T, Mertens L, Schepers D, Vinckx J, Gewilling M. Assessment of cardiovascular exercise function in obese children and adolescents by body mass- independent parameters. *European Journal of Applied Physiology*. 1997; 75:478–483.
- Rich-Edwards JW, Stampfer MJ, Manson JE, Rosner B, Hankinson SE, Colditz GA, Willett WC, Hennekens CH. Birth weight and risk of cardiovascular disease in a cohort of women followed up since 1976. *BMJ*. 1997; 315:396–400. [PubMed: 9277603]
- Sewell, WH.; Hauser, RM.; Springer, KW.; Hauser, TS. As we age: A review of the Wisconsin Longitudinal Study, 1957–2001. In: Leicht, KT., editor. *Research in Social Stratification and Mobility*. Vol. 20. Oxford: Elsevier; 2004. p. 3-114.
- Simonsick EM, Newman AB, Visser M, Goodpaster B, Krichevsky SB, Rubin S, Nevitt MC, Harris TB. for the Health Aging and Body Composition Study. Mobility limitation in self-described well-functioning older adults: importance of endurance walk testing. *Journals of Gerontology A Biological Sciences and Medical Sciences*. 2008; 63:841–847. [PubMed: 18772472]
- Smith JP. Reconstructing childhood health histories. *Demography*. 2009; 46:387–403. [PubMed: 21305399]
- Sowers M, Pope S, Welch G, Sternfeld B, Albrecht G. The association of menopause and physical functioning in women at midlife. *Journal of the American Geriatric Society*. 2001; 49:1485–1492.
- Stein CE, Fall CHD, Kumaran K, Osmond C, Cox V, Barker DJP. Fetal growth and coronary heart disease in south India. *Lancet*. 1996; 348:1269–1273. [PubMed: 8909379]
- Strauss RS. Childhood obesity and self-esteem. *Pediatrics*. 2000; 105:15.
- Van Lenthe FJ, Kemper HCG, van Mechelen W. Rapid maturation in adolescence results in greater obesity in adulthood: the Amsterdam Growth and Health Study. *American Journal of Clinical Nutrition*. 1996; 64:18–24. [PubMed: 8669409]
- Wright CM, Parker L, Lamont D, Craft AW. Implications of childhood obesity for adult health: findings from thousand families cohort study. *British Medical Journal*. 2001; 323:1280–1284. [PubMed: 11731390]
- Yu X, Fujimoto K, Urushibata K, Matsuzawa Y, Kubo K. Cephalometric analysis in obese and nonobese patients with obstructive sleep apnea syndrome. *Chest*. 2003; 124:212–218. [PubMed: 12853525]

Table 1

Descriptive characteristics

	n=4166
High School Weight	%
Normal Weight	43.0
Underweight	10.0
Risk of Overweight	35.9
Overweight	11.1
Adult BMI (1993)	
Normal Weight	34.0
Underweight	00.5
Overweight	42.6
Obese	22.9
Mean Family Income (1957)	6431
Head of Household Education	
Less than 8th grade	18.9
Grades 8–11	41.8
HS Diploma	25.2
Some College or More	14.1
Child Health	
Good	84.0
Poor	16.0
Sex of Respondent	
Male	45.9
Female	54.1

Table 2

Difficulty completing a physical function measure by adolescent body weight in females (Panel 1) and males (Panel 2) (reported in percent unless otherwise stated)

	Females n=2252			
	Normal weight	Low weight	Excess weight	Total
HUI3 Score (mean)	0.97	0.99	0.97	0.97
Limitation Score (mean)	1.48	1.19	1.58	1.55
Stairs	9.37	6.36	13.03	11.55
Lift 25 lbs	38.55	35.17	35.66	37.88
Push/Pull Objects	24.39	16.10	21.68	23.22
Stand for 1 Hr.	20.34	13.14	22.99	21.63
Sit for 1 Hr.	6.92	2.54	6.28	6.39
Kneel	40.68	39.41	47.51	44.85
Reach above Head	7.99	6.36	10.90	9.72

	Males n=1914			
	Normal Weight	Low weight	Excess weight	Total
HUI3 Score (mean)	0.99	0.99	0.98	0.98
Limitation Score (mean)	0.72	0.77	0.83	0.80
Stairs	4.94	4.97	5.68	5.59
Lift 25 lbs	8.11	7.73	8.45	8.78
Push/Pull Objects	8.93	6.63	9.06	9.40
Stand for 1 Hr.	13.40	16.57	16.13	15.26
Sit for 1 Hr.	3.29	3.31	4.45	4.18
Kneel	28.08	30.39	31.80	30.46
Reach above Head	5.64	7.73	7.37	6.53

Table 3

Effect of adolescent body weight on the Health Utilities Index: Ambulation Scale score from OLS regression models

	(standard error in parenthesis)			
	(1) Female n=2252	(2) Female n=2252	(3) Male n=1914	(4) Male n=1914
Underweight	0.012 (0.009)	0.009 (0.009)	0.000 (0.007)	−0.001 (0.007)
Risk of Overweight	−0.007 (0.006)	−0.001 (0.006)	−0.013 (0.005) ***	−0.011 (0.005) **
Overweight	−0.035 (0.010) ***	−0.021 (0.010) **	−0.017 (0.007) ***	−0.014 (0.007) **
Log Income (1957)	−0.003 (0.004)	−0.003 (0.004)	−0.001 (0.003)	−0.001 (0.003)
Grades 8–11	0.012 (0.008)	0.012 (0.008)	0.005 (0.006)	0.005 (0.006)
High School	0.008 (0.008)	0.007 (0.008)	0.009 (0.006)	0.009 (0.006)
Some College	0.011 (0.010)	0.007 (0.010)	0.015 (0.007) **	0.014 (0.007) *
Poor Child Health	−0.020 (0.007) ***	−0.020 (0.007) ***	−0.004 (0.006)	−0.004 (0.006)
Overweight Adult BMI		−0.012 (0.006) **		−0.004 (0.005)
Obese Adult BMI		−0.057 (0.007) ***		−0.011 (0.006) *
Underweight Adult BMI		−0.080 (0.028) ***		
Constant	0.992 (0.037) ***	1.012 (0.037) ***	0.991 (0.027) ***	0.995 (0.028) ***
R-squared	0.013	0.041	0.009	0.011

p<0.01,

**
p<0.05,

*
p<0.1

Reference groups = Normal weight in adolescence; Less than 8th grade education; Normal weight Adult BMI

Table 4

Effect of adolescent body weight on the physical limitations score from OLS regression models

(standard error in parenthesis)

	(1) Female n=2252	(2) Female n=2252	(3) Male n=1914	(4) Male n=1914
Underweight	−0.282 (0.126) **	−0.201 (0.121) *	0.030 (0.112)	0.063 (0.111)
Risk of Overweight	0.085 (0.082)	−0.054 (0.080)	0.108 (0.071)	0.040 (0.071)
Overweight	0.574 (0.128) ***	0.232 (0.125) *	0.305 (0.101) ***	0.147 (0.103)
Log Income (1957)	−0.022 (0.058)	−0.005 (0.056)	−0.019 (0.049)	−0.020 (0.049)
Grades 8–11	−0.091 (0.102)	−0.093 (0.098)	−0.145 (0.086) *	−0.130 (0.085)
High School	−0.156 (0.113)	−0.138 (0.108)	−0.219 (0.095) **	−0.196 (0.094) **
Some College	−0.271 (0.133) **	−0.141 (0.128)	−0.156 (0.113)	−0.106 (0.112)
Poor Child Health	0.302 (0.097) ***	0.319 (0.093) ***	0.220 (0.088) **	0.247 (0.087) ***
Overweight Adult BMI		0.359 (0.080) ***		0.221 (0.079) ***
Obese Adult BMI		1.377 (0.097) ***		0.589 (0.093) ***
Underweight Adult BMI		0.682 (0.368) *		
Constant	1.741 (0.498) ***	1.240 (0.480) ***	0.995 (0.421) **	0.748 (0.421) *
R-squared	0.022	0.103	0.012	0.033

p<0.01,**
p<0.05,*
p<0.1Reference groups = Normal weight in adolescence; Less than 8th grade education; Normal weight Adult BMI