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# Obesity's Effects on the Onset of Functional Impairment Among Older Adults

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**Purpose:** This study has two purposes. First, it determines if there is a relationship between body weight and the onset of functional impairment across time among this sample of older adults. More specifically, it examines if obese older adults are more likely to experience the onset of functional impairment. Second, it explores how health behaviors and health conditions may explain the relationship between body weight and the onset of functional impairment. **Design and Methods:** With the use of longitudinal data from the Asset and Health Dynamics Among the Oldest Old (AHEAD) survey, logistic regression models on the onset of functional impairment over two time points are estimated for older adults. **Results:** Results indicate that body weight (more specifically being overweight or obese) makes one more likely to experience the onset of functional impairment across various domains of impairment. Outside of health behaviors and health conditions, obesity has an independent effect on the onset of impairment in strength, lower body mobility, and activities of daily living. **Implications:** Study findings support the active treatment of weight problems in older adults. Future directions for research in this area should address effective weight management interventions targeting issues related to older individuals.

*Key Words: Obesity, Overweight, Functional impairment, Health conditions*

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Excessive weight is a growing and costly problem that requires public attention. According to data from the National Health and Nutrition Examination Survey (NHANES), the prevalence of obesity in adults increased from about 14.5% in 1980 to 22.5% in 1994 (Flegal, Carrol, Kuczmarski, & Johnson, 1998; Mokdad et al., 1999). Related to increasing prevalence, obesity is associated with increased health care costs. One estimate is that obesity-related morbidity may account for 5.7% of health care costs in the United States (Wolf & Colditz, 1998). Although the causes and consequences of obesity among young and middle-age individuals have been explored in recent years, less attention has been focused on understanding the influence of excessive weight among older adults (see Himes, 2000, and Jensen & Friedmann, 2002, for exceptions), defined here as men and women who were born in or prior to 1923.

The rapidly growing older population in the United States and increased functional impairment in old age (Hebert, Brayne, & Spiegelhalter, 1997) indicate that modifiable risk factors for morbidity must be identified in order to develop interventions that either delay the onset of or improve the recovery from functional impairments. Excessive body weight may be a modifiable risk factor, but little work has focused on its relationship to the onset of functional impairment across time among older adults. The research reported here seeks to address this gap in the literature.

### *Body Weight and Functional Impairment*

Several studies have analyzed the relationship between body weight and functional impairment (Clark & Mungai, 1997; Tully & Snowdon, 1995), showing that extreme high or low body weight is associated with poorer physical functioning (Bannerman et al., 2002; Clark, Callahan, Mungai, & Wolinsky, 1996; Friedmann, Elasy, & Jensen, 2001; Jensen & Friedmann, 2002; Launer, Harris, Rumpel, & Madans, 1994). In one study, Ferraro and Booth (1999) found that being either obese or underweight is associated with higher rates of functional illness among the adult population. Himes (2000) found similar results in an analysis of two samples of individuals who were 70 years of age or older in 1984 and 1993–1994: Obesity (vs. normal weight) was associated with an increased prevalence of diseases such as diabetes, hypertension, and arthritis and also functional impairment. These studies suggest that body weight may be an important risk factor for functional impairment in later life. Ferraro and Booth (1999) included longitudinal analyses, but their data described a broad age spectrum. Himes (2000) and Jensen and Friedmann (2002) explored the effects of body weight among older cohorts. However, Himes' study was cross-sectional and Jensen and Friedmann's sample was not nationally representative. The present study expands on these past studies by examining the relationship between body weight and the onset of functional impairment, using a nationally representative older adult cohort.

Researchers have found several physiological pathways for the influence of high body weight on functioning (Launer et al., 1994). First, excessive body weight typically contributes to inflammation of the tissues of joints, making ambulating painful and difficult (Walford, Harris, & Weindruch, 1987). Second, it also increases the amount of mechanical stress placed on body joints, elevating the risk for and severity of osteoarthritis (Clark & Mungai, 1997; Hart & Spector, 1993) and increasing functional impairment. Third, excess weight is associated with a sedentary lifestyle, which contributes to decreased muscle strength and cardiovascular fitness and may eventually result in difficulties with physical functions such as walking several blocks or climbing a flight of stairs (Himes, 2000).

The relationship between body weight and the onset of functional impairment is complex in that body weight may affect the onset of functional impairment in part by affecting health behaviors. For example, obesity can restrict activities (Stewart & Brook, 1983), making one less likely to experience the beneficial effects of exercise (Seeman & Chen, 2002). In addition, having a lower body mass index (BMI) and being underweight are associated with smoking behavior (Molarius, Seidell, Kuulasmaa, Dobson, & Sans, 1997), possibly because smoking suppresses appetite (Perkins et al., 1991). Smoking can hamper the body's ability to use oxygen, making breathing and in turn certain activities difficult (Stuck et al., 1999).

Body weight may also affect the onset of functional impairment through its relationship to certain diseases. Obesity is a contributing factor for heart disease, hypertension, cancer, diabetes, and stroke (Jousilahti, Vartiainen, Tuomilehto, & Puska, 1999; Must et al., 1999). Side effects and symptoms of these illnesses may then contribute to the onset of functional impairment (Verbrugge & Jette, 1994). Being underweight, however, may be associated with an occult disease that would subsequently lead to the diagnosis of a health condition (such as cancer) at a more advanced stage (Marton, Sox, & Krupp, 1981).

In sum, research on young and middle-age populations suggests an association between body weight and functional impairment and a variety of possible linking mechanisms. The research along this line of inquiry that contains large population-based samples of older adults is mostly cross-sectional (see Himes, 2000). I analyze the relationship between body weight and the onset of functional impairment to answer two broad research questions not addressed in the literature: First, is there a relationship between body weight and the onset of functional impairment across time among older adults? Second, can this relationship be explained by health behaviors and conditions? More specifically, I expect that outside of health behaviors and conditions, older adults who are obese (vs. normal weight) will be more likely to experience the onset of functional impairment.

## Methods

I used data from two waves of the Asset and Health Dynamics Among the Oldest Old (AHEAD) survey, 1995 and 1998, to examine the influence of body weight on the onset of functional impairment. The AHEAD survey is a longitudinal study of a nationally representative sample of men and women aged 70 and older in 1993 (and their spouses). I conducted analyses to examine the impact of the clustering of spouses on the results; the clustering of data does not appear to affect the overall relationships. The total sample size differs across the functional outcomes based on how *onset* of functional impairment is defined. I consider only persons who are free of a strength impairment in 1995, for example, in the analysis of the onset of strength impairment in 1998. Because each of the four impairment domains is not mutually exclusive (e.g., being free of a strength impairment does not exclude one from having a lower body mobility impairment), the number of cases vary across the outcomes. The total number of respondents for each outcome is 1,418 (strength impairment), 2,460 (lower body mobility impairment), 2,554 (upper body mobility impairment), and 3,373 (activities of daily living impairment). The AHEAD data include detailed information on socioeconomic and demographic characteristics, body weight, health behaviors (i.e., smoking, drinking, and exercise), health conditions, and functional impairment. Also included is information on insurance, family structure, family transfers, housing, cognitive functioning, net worth, and income. AHEAD data are a valuable source of secondary information that allows for the longitudinal examination of the impact of body weight on the onset of functional impairment among older adults.

I omitted data on physical functioning from 1993 as a result of differences in question wording. Question wording for the functional measures is comparable in 1995 and 1998.

## Measurement of Functional Impairment (Measured in 1998)

I assessed functional impairment with four summary measures: strength, upper body mobility, lower body mobility, and ability to perform activities of daily living (ADLs). Distinguishing between various domains of functioning is important in detecting a relationship between body weight and the onset of functional impairment. The use of global measures of functioning may mask the specific type or domain of impairment that body weight or other risk factors may influence (Ferraro, Su, Gretebeck, Black, & Badylak, 2002).

Construction of these measures is similar with the literature in this area (Wallace & Herzog, 1995). Strength is gauged by use of yes–no–can't do answers to four questions about whether respondents have any difficulty sitting for 2 hr or longer; stooping, kneeling, or crouching; getting up from a chair after sitting for long periods; and pulling or pushing large objects such as a living room chair. Upper body mobility is gauged by use of yes–no–can't do answers to three questions about having difficulty lifting or carrying an object that weighs over 10 lb (such as a bag of groceries); picking up a dime from a table; and lifting arms above the shoulder level. Lower body mobility is measured by use of yes–no–can't do answers to three questions about having difficulty walking several blocks, walking one block, and climbing one flight of stairs. ADL function is derived from yes–no–can't do answers to four questions about having difficulty performing activities such as dressing, bathing, eating, or getting out of bed.

The response categories for each of the individual functioning measures are yes–no–can't do–don't do and thus I coded them as 1 = yes–can't do, impaired and 0 = no, not impaired; I set don't do to missing. I then collapsed responses to questions in each functional domain (e.g., strength) into two categories: no impairment (0 = no reported difficulty with any activity) versus some impairment (1 = difficulty with one or more activity). I considered only those who responded "no" to all difficulty questions in a given functional area to have no impairment in that area.

## Measurement of BMI (Measured in 1995)

I assessed BMI, a measure of weight for height, by using self-reports of height (measured in feet and inches) and weight (measured in pounds). Because height was not assessed again in 1995, I used a lagged measure of height (1993 height) in the calculation of BMI. I then calculated BMI as follows: (weight in kilograms)/(height in square meters). Next, I categorized BMI according to the National Heart, Lung and Blood Institute (NHLBI) guidelines for body weight. Those categories are defined as follows: underweight = BMI $< 18.5$, normal weight = BMI 18.5–24.9, overweight = BMI 25.0–29.9, and obese = BMI 30.0 and over (NHLBI, 1998). Normal weight is used as the reference category in multivariate analyses. The NHLBI definition of body weight was selected because it is used by medical practitioners for the clinical assessment and treatment of problems associated with body weight. In addition, being underweight is important to consider in such analyses because of the U-shaped relationship between body weight and poorer health outcomes (Galanos, Pieper, Cornoni-Huntley, Bales, & Fillenbaum, 1994). Thus, excluding underweight subjects from analyses or using a linear form of BMI may not provide an accurate assessment of the effect of body weight on functioning (Ferraro & Booth, 1999).

Finally, it is important to note that self-reported measures of height and weight are found to be predictive of health outcomes (Stunkard & Albaum, 1981; Troy et al., 1995). However, this type of measurement may also result in underestimating BMI because people of short stature overreport their height and heavy individuals underreport their weight (Black, Taylor, & Coster, 1998; Ferraro & Booth, 1999; Kuskowska-Wolk, Bergstrom, & Bostrom, 1992). Therefore, this measurement may produce conservative prevalence estimates of obesity but not necessarily have an effect on any correlations with obesity.

## Measurement of Other Independent Variables (1995)

*Socioeconomic and Demographic Controls (1995).*—I measured age in years. Men and women's rates of functional impairment are different, with women living longer than men yet having higher morbidity rates (Dunlop, Hughes, & Manheim, 1997). Therefore, I included gender and constructed it as a dummy variable (1 = male, 0 = female). Because of the small number of respondents in some race categories, I collapsed race into three categories: African American (non-Hispanic), Latino, and White (non-Hispanic). In the multivariate analyses, White is used as the reference category. People who are married tend to be healthier across a wide range of health outcomes than those who are not married (Pienta, Hayward, & Jenkins, 2000). Because marital status is important to consider, I created a dummy variable (1 = married, 0 = not married). Certain socioeconomic factors are also shown to affect one's functional status (Kington & Smith, 1997; Snowdon, Ostwald, & Kane, 1989). Thus, I defined income as income from all household members, including sources of support such as disability and worker's compensation benefits. I used the natural logarithm of household income in the multivariate analyses to linearize the effect of the skewed distribution. I measured years of complete education as a continuous variable (range: 0–17).

*Health Behaviors (1995).*—I expected health behaviors to be important correlates of body weight and the onset of functional impairment. I included three health behaviors in the models: cigarette smoking, binge drinking, and exercise. I evaluated smoking behavior by classifying individuals according to whether or not they are current smokers (=1). I measured binge drinking by a participant's response to this question: "In the past 3 months, on how many days have you had four or more drinks on one occasion (range: 0–92)?" Exercise, which I measured as a dummy variable, is based on a respondent's answer to this question: "On average, over the past 12 months have you participated in vigorous physical activity or exercise three times a week or more (1 = no and 0 = yes)?"

*Health Conditions (1995).*—I based serious conditions on self-reports of physician-diagnosed serious health conditions. Respondents were asked if a doctor has ever told them that they have high blood pressure or hypertension; diabetes or high blood sugar; cancer or a malignant tumor of any kind (excluding skin cancer); chronic lung disease such as chronic bronchitis or emphysema; heart problems; arthritis; or a stroke. I created a comorbidity index by summing the number of reported conditions (range: 0–7).

I constructed a measure of symptoms based on respondents' experience of any of the following "persistent or troublesome problems": leg pain or leg cramps at night; persistent swelling in feet or ankles; shortness of breath while awake; persistent dizziness or lightheadedness; back pain or problems; persistent headaches; severe fatigue or exhaustion; persistent wheezing, coughing, or bringing up phlegm; or difficulty or burning when urinating (yes = 1, no = 0). I summed these nine responses to create a continuous measure of symptoms.

Functional impairments in 1995 may affect the onset of impairment in other domains in 1998, so I used them as control variables. For example, strength, ADLs, or upper body mobility impairment in 1995 may be important, when the dependent variable of interest is onset of lower body mobility limitation in 1998. I included measures of strength, ADLs, and upper body mobility in 1995 as independent variables in the exploration of the relationship between body weight and the onset of a lower body mobility impairment measured in 1998.

## Analysis

Because the four dependent variables (strength, upper body mobility, lower body mobility, and ADLs) are dichotomous measures, I used logistic regression to estimate the probability of onset of functional impairment. To understand the relative impact of each set of independent variables (health behaviors and health conditions) on the relationship between body weight and the onset of functional impairment, I estimated a hierarchical set of models for each dependent variable. Model 1 estimates the effects of socioeconomic and demographic controls (i.e., age, gender, race, marital status, income, and education) and body weight. Model 2 adds health behaviors, and the next successive model introduces the remaining variable set (health conditions).

I imputed and analyzed data by using IVEware software (Raghunathan, Solenberger, & Van Hoewyk, 2000) that accounts for the weighting and complex sample design of the AHEAD survey (Heeringa & Connor, 1995). The AHEAD staff also provided sample weights that I used to weight these analyses appropriately. Missing data (across all functional domains) ranged from less than 0.25% to less than 10% of the sample, with serious conditions having the most missing data. Imputation procedures with IVEware software use the sequential regression method (Raghunathan, Lepkowski, Van Hoewyk, & Solenberger 1998)—either linear, logistic, or multinomial, depending on whether the variable is a continuous or categorical measure—to impute data contained in complex survey designs. This method performs imputations by considering the other variables in the data set, beginning with the characteristic that has the least amount of missing data, and repeats the procedures until convergence occurs.

I recognize that sample attrition (through mortality or nonresponse) may affect the measurement of the dependent variable. To better estimate the effect that attrition has on my sample, I reviewed multinomial logistic regression results considering the following mutually exclusive and jointly exhaustive outcomes: died, nonresponse–proxy respondent, was impaired in a specified domain, or was not impaired in a specified domain. Because the dependent variable in the original analyses, onset of functional impairment, is measured in 1998, the attrition was allowed to occur by 1998. I examined the multinomial logistic regression for each of the four functional domains separately, with "not impaired" being the reference category. The results of the attrition analyses indicate that persons who are underweight are more likely to attrite as a result of death. Thus, by including persons in the sample who completed both the 1995 and 1998 surveys, I am examining a healthier group of older adults. This may result in an underestimation of the effect that body weight, particularly being underweight, has on the onset of functional impairment because persons who are underweight are frailer and more likely to experience impairment prior to exiting the sample.

# Results

Table 1 examines descriptive characteristics for the full sample (column 2) and the bivariate relationships (columns 3–6) of body weight and

**Table 1. Descriptive and Bivariate Results: The Relationships Among Socioeconomic and Demographic Controls, Body Weight, Health Conditions, and Functional Impairment Among Older Adults**

| | | Strength | | Lower Body Mobility | | Upper Body Mobility | | ADLs | |
|---|---|---|---|---|---|---|---|---|---|
| | Full Sample | Not Impaired | Impaired | Not Impaired | Impaired | Not Impaired | Impaired | Not Impaired | Impaired |
| Socioeconomic and demographic controls | | | | | | | | | |
| Age (*M*) | 78.0 (4.9) | 76.8 | 78.0*** | 76.9 | 78.6*** | 77.1 | 78.7*** | 77.4 | 79.8** |
| Male (%) | 37.8 | 51.2 | 43.8* | 45.4 | 32.8*** | 48.9 | 33.7*** | 40.5 | 29.7** |
| Race (%) | | | | | | | | | |
| African American | 6.7 | 5.8 | 6.0 | 4.8 | 6.4* | 5.1 | 6.1 | 5.8 | 9.0* |
| Latino | 2.7 | 3.1 | 2.2 | 2.4 | 2.1 | 2.7 | 2.9 | 2.5 | 2.3 |
| White | 90.6 | 91.1 | 91.8 | 92.8 | 91.6 | 92.2 | 90.9 | 91.7 | 88.7* |
| HH income (*M*) | 31,614 (40,364) | 39,765 | 32,129 | 37,743 | 28,202* | 38,024 | 26,595*** | 34,400 | 26,082** |
| Education (*M*) | 11.7 (3.3) | 12.4 | 11.8** | 12.3 | 11.6*** | 12.2 | 11.2*** | 12.0 | 11.0** |
| Married (%) | 51.6 | 58.8 | 55.5 | 59.2 | 45.4*** | 60.2 | 44.6*** | 55.2 | 42.4** |
| Body weight (BMI; %) | | | | | | | | | |
| Underweight | 2.9 | 2.4 | 2.6 | 2.6 | 2.6 | 2.2 | 2.6 | 2.8 | 2.0 |
| Normal weight | 46.3 | 55.7 | 46.4*** | 51.8 | 43.3** | 48.2 | 46.4 | 48.6 | 44.5 |
| Overweight | 37.2 | 35.9 | 40.8 | 37.4 | 40.1 | 39.5 | 37.2 | 37.7 | 33.5 |
| Obese | 13.5 | 6.0 | 10.2* | 8.1 | 14.0*** | 10.1 | 13.7* | 10.9 | 20.0** |
| Health behaviors | | | | | | | | | |
| Binge drinker (*M*) | 0.6 (6.2) | 1.1 | 0.4 | 0.7 | 0.2* | 0.9 | 0.8 | 0.7 | 0.3 |
| Current smoker (%) | 7.3 | 7.7 | 8.2 | 5.7 | 6.5 | 6.7 | 9.1 | 7.2 | 9.0 |
| Does not exercise (%) | 63.6 | 46.4 | 55.9** | 48.5 | 64.6*** | 51.7 | 68.2*** | 57.5 | 74.1** |
| Health conditions | | | | | | | | | |
| Serious conditions (*M*) | 1.8 (1.2) | 1.2 | 1.4*** | 1.5 | 1.8*** | 1.5 | 1.9*** | 1.6 | 2.2** |
| Symptoms (*M*) | 1.8 (1.8) | 0.7 | 1.1*** | 1.1 | 1.6*** | 1.1 | 1.9*** | 1.4 | 2.4** |
| 1998 strength impairment (%) | 68.7 | | | | | | | | |
| 1998 lower body mobility impairment (%) | 44.6 | | | | | | | | |
| 1998 upper body mobility impairment (%) | 43.4 | | | | | | | | |
| 1998 ADL impairment (%) | 21.1 | | | | | | | | |

*Notes*: Standard deviations are given in parentheses. Data in this table are weighted and adjusted for the complex survey design. The source of the data is the Asset and Health Dynamics Among the Oldest Old survey (1995 and 1998). The numbers for the sample are as follows. Full sample, $N = 4{,}087$; strength, $n = 1{,}418$; lower body mobility, $n = 2{,}460$; upper body mobility, $n = 2{,}554$; ADLs, $n = 3{,}373$. ADL = activities of daily living; HH = household; BMI = body mass index.

$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

Table 2. Results: Logistic Regression Models of the Onset of a Strength Impairment by Socioeconomic and Demographic Controls, Body Weight, Health Behaviors, and Health Conditions ($n$ = 1,418)

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | OR | CI | OR | CI | OR | CI |
| Socioeconomic and demographic controls | | | | | | |
| Age | 1.06*** | (1.04–1.09) | 1.06*** | (1.03–1.09) | 1.05*** | (1.02–1.08) |
| Male | 0.68** | (0.51–0.90) | 0.70* | (0.53–0.93) | 0.72* | (0.53–0.97) |
| African American | 0.83 | (0.49–1.38) | 0.80 | (0.48–1.34) | 0.69 | (0.40–1.17) |
| Latino | 0.56* | (0.33–0.95) | 0.52* | (0.31–0.87) | 0.53* | (0.31–0.90) |
| Married | 1.23 | (0.95–1.61) | 1.21 | (0.92–1.60) | 1.18 | (0.90–1.54) |
| HH income | 0.96 | (0.81–1.13) | 0.96 | (0.82–1.13) | 0.97 | (0.84–1.11) |
| Education | 0.96 | (0.91–1.01) | 0.96 | (0.92–1.01) | 0.96 | (0.91–1.00) |
| Body weight | | | | | | |
| Underweight | 1.17 | (0.50–2.73) | 1.10 | (0.48–2.53) | 1.06 | (0.46–2.43) |
| Overweight | 1.47*** | (1.17–1.86) | 1.47** | (1.16–1.87) | 1.48** | (1.15–1.91) |
| Obese | 2.26*** | (1.40–3.64) | 2.19*** | (1.38–3.47) | 2.17** | (1.32–3.56) |
| Health behaviors | | | | | | |
| Binge drinker | | | 0.99 | (0.97–1.01) | 0.99 | (0.98–1.01) |
| Current smoker | | | 1.22 | (0.67–2.22) | 1.22 | (0.68–2.19) |
| Does not exercise | | | 1.33* | (1.05–1.70) | 1.22 | (0.96–1.55) |
| Health conditions | | | | | | |
| Serious conditions | | | | | 1.10 | (0.97–1.25) |
| Symptoms | | | | | 1.27*** | (1.13–1.43) |
| Lower body mobility impairment | | | | | 1.59 | (0.98–2.57) |
| Upper body mobility impairment | | | | | 1.89*** | (1.30–2.75) |
| ADL impairment | | | | | 0.44 | (0.10–1.90) |
| Model fit (log likelihood) | 1,815.65 | | 1807.07 | | 1,751.43 | |

*Notes*: The 95% confidence interval (CI) is given in parentheses. Data in this table are weighted and adjusted for the complex survey design. The source of the data is the Asset and Health Dynamics Among the Oldest Old survey (1995 and 1998). The reference category for race is White; that for body weight is normal weight. OR = odds ratio; HH = household; ADL = activities of daily living.

$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

other characteristics with the onset of functional impairment. It shows that, compared with those not impaired, persons who are impaired in 1998 are older and have lower levels of education and household income (with the exception of strength impairment). Considering body weight, one can see that a greater proportion of obese individuals experience the onset of impairment.

Reviewing the health behaviors, we notice that there is a statistically significant relationship between exercise and the onset of functional impairment that is in the expected direction. Larger proportions of older adults who do not participate in regular exercise experience the onset of functional impairment, and this is true across all four functional domains.

Health conditions are also related to the onset of functional impairment across all four functional domains. Persons who experience the onset of functional impairment have a greater number of serious conditions and symptoms compared with those older adults who remain free of impairment.

### *Obesity and the Onset of Functional Impairment*

I present the multivariate logistic regression results in the form of odds ratios (ORs). A value of more than 1.0 indicates a greater likelihood of experiencing the onset of functional impairment, whereas an OR of less than 1.0 indicates a lower likelihood of experiencing the onset of functional impairment. I also conducted additional analyses that used ordinary least squares (OLS) regression and controlled for 1995 functioning measures (rather than selecting those who were free of impairment) to predict a continuous version of the 1998 functioning measures. These analyses showed highly similar results compared with the logistic regression analyses.

The first model presented in Table 2 includes 1995 socioeconomic and demographic controls and body weight as predictors of the onset of a strength impairment. Respondents who are older and overweight or obese (vs. normal weight) are more likely to experience the onset of a strength impairment. Those who are male or Latino (vs. White) are less likely to experience a strength impairment.

I added health behaviors in Model 2. There is little change in body weight with the addition of health behaviors. Being overweight or obese still increases the likelihood of experiencing the onset of a strength impairment. However, the effect of being overweight is reduced in significance with the addition of health behaviors. In addition, the likelihood of experiencing

Table 3. Results: Logistic Regression Models of the Onset of a Lower Body Mobility Impairment by Socioeconomic and Demographic Controls, Body Weight, Health Behaviors, and Health Conditions ($n$ = 2,460)

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | OR | CI | OR | CI | OR | CI |
| Socioeconomic and demographic controls | | | | | | |
| Age | 1.08*** | (1.06–1.10) | 1.08*** | (1.06–1.10) | 1.08*** | (1.05–1.10) |
| Male | 0.63*** | (0.48–0.83) | 0.66** | (0.50–0.88) | 0.73* | (0.55–0.98) |
| African American | 1.00 | (0.72–1.39) | 0.96 | (0.68–1.36) | 0.96 | (0.65–1.41) |
| Latino | 0.64 | (0.37–1.09) | 0.59* | (0.34–1.01) | 0.65 | (0.37–1.13) |
| Married | 0.85 | (0.65–1.11) | 0.86 | (0.66–1.12) | 0.82 | (0.61–1.10) |
| HH income | 0.92 | (0.80–1.05) | 0.92 | (0.81–1.04) | 0.92 | (0.81–1.04) |
| Education | 0.96* | (0.93–1.00) | 0.96* | (0.93–1.00) | 0.96* | (0.93–1.00) |
| Body weight | | | | | | |
| Underweight | 1.01 | (0.58–1.77) | 0.91 | (0.51–1.60) | 0.88 | (0.49–1.58) |
| Overweight | 1.49** | (1.13–1.95) | 1.47** | (1.11–1.96) | 1.48* | (1.08–2.03) |
| Obese | 2.43*** | (1.62–3.64) | 2.34*** | (1.56–3.51) | 2.07** | (1.31–3.27) |
| Health behaviors | | | | | | |
| Binge drinker | | | 0.98* | (0.96–1.00) | 0.98* | (0.97–1.00) |
| Current smoker | | | 1.41 | (0.89–2.22) | 1.61 | (0.98–2.67) |
| Does not exercise | | | 1.71*** | (1.31–2.23) | 1.55** | (1.18–2.03) |
| Health conditions | | | | | | |
| Serious conditions | | | | | 1.17** | (1.05–1.29) |
| Symptoms | | | | | 1.20*** | (1.11–1.29) |
| Strength impairment | | | | | 1.62*** | (1.26–2.08) |
| Upper body mobility impairment | | | | | 1.67*** | (1.25–2.24) |
| ADL impairment | | | | | 0.80 | (0.42–1.52) |
| Model fit (log likelihood) | 2,360.67 | | 2,330.58 | | 2,209.77 | |

*Notes*: The 95% confidence interval (CI) is given in parentheses. Data in this table are weighted and adjusted for the complex survey design. The source of the data is the Asset and Health Dynamics Among the Oldest Old survey (1995 and 1998). The reference category for race is White; that for body weight is normal weight. OR = odds ratio; HH = household; ADL = activities of daily living.

*$p < .05$; **$p < .01$; ***$p < .001$.

the onset of a strength impairment is greater among those who do not exercise (OR = 1.33).

With the addition of health conditions in Model 3, the previous relationships with body weight change. Although the effect of obesity is partly explained with this addition, both being overweight and being obese still have an independent effect. In addition, persons who have upper body mobility impairment or a greater number of symptoms are more likely to experience the onset of a strength impairment.

In Table 3, the onset of a lower body mobility is investigated. Model 1 indicates that older, overweight or obese (vs. normal weight) respondents are more likely to experience the onset of a lower body mobility impairment. In contrast, men or those who completed more years of education are less likely to experience a lower body impairment.

In Model 2, I added health behaviors and body weight still has an effect. Obese and overweight adults and those who do not exercise are more likely to experience a lower body mobility impairment, whereas persons who have four or more drinks per day are less likely to experience the onset of this impairment.

With the addition of health conditions in Model 3, the effect of being overweight and obese is partly explained. In addition, having a greater number of serious conditions, symptoms, or a strength or upper body mobility impairment contributes to the onset of a lower body mobility impairment.

Table 4 includes the same set of hierarchical models as the previous multivariate tables, but it analyzes the onset of upper body mobility impairment. Model 1, which considers only socioeconomic and demographic controls and body weight, indicates that respondents who are older or obese are more likely to experience the onset of an upper body mobility impairment. Older adults who are male or have higher levels of education are less likely to experience the onset of impairment in this domain.

In Model 2, body weight still has an effect. Persons who are obese are more likely to experience an upper body impairment. Reviewing the health behaviors, one can see that smoking and not exercising increase the risk of experiencing the onset of an upper body mobility impairment.

In Model 3, the fully specified model, we observe that with the addition of health conditions there is no longer an effect with body weight. Each of the health conditions works in the expected direction. That is, those with a greater number of serious conditions (OR = 1.21) or symptoms (OR = 1.18), or impairments of strength (OR = 1.74), lower body

Table 4. Results: Logistic Regression Models of the Onset of a Upper Body Mobility Impairment by Socioeconomic and Demographic Controls, Body Weight, Health Behaviors, and Health Conditions ($n$ = 2,554)

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | OR | CI | OR | CI | OR | CI |
| Socioeconomic and demographic controls | | | | | | |
| Age | 1.06*** | (1.03–1.08) | 1.05*** | (1.03–1.08) | 1.04** | (1.01–1.06) |
| Male | 0.62*** | (0.48–0.81) | 0.64*** | (0.49–0.83) | 0.62*** | (0.46–0.82) |
| African American | 0.81 | (0.57–1.15) | 0.77 | (0.55–1.07) | 0.78 | (0.57–1.07) |
| Latino | 0.64 | (0.39–1.04) | 0.58* | (0.35–0.95) | 0.57* | (0.36–0.92) |
| Married | 0.81 | (0.63–1.04) | 0.82 | (0.64–1.06) | 0.79 | (0.62–1.02) |
| HH income | 0.89 | (0.78–1.02) | 0.90 | (0.79–1.02) | 0.89* | (0.81–0.99) |
| Education | 0.92*** | (0.90–0.95) | 0.93*** | (0.90–0.95) | 0.94*** | (0.90–0.97) |
| Body weight | | | | | | |
| Underweight | 0.98 | (0.61–1.60) | 0.89 | (0.55–1.46) | 0.93 | (0.54–1.58) |
| Overweight | 1.09 | (0.83–1.43) | 1.10 | (0.83–1.46) | 1.02 | (0.76–1.37) |
| Obese | 1.48* | (1.07–2.05) | 1.41* | (1.01–1.95) | 1.01 | (0.69–1.48) |
| Health behaviors | | | | | | |
| Binge drinker | | | 1.00 | (0.98–1.02) | 1.00 | (0.98–1.02) |
| Current smoker | | | 1.48* | (1.01–2.18) | 1.46 | (0.98–2.19) |
| Does not exercise | | | 1.73*** | (1.40–2.15) | 1.36** | (1.08–1.71) |
| Health conditions | | | | | | |
| Serious conditions | | | | | 1.21*** | (1.10–1.32) |
| Symptoms | | | | | 1.18*** | (1.08–1.30) |
| Strength impairment | | | | | 1.74*** | (1.31–2.32) |
| Lower body mobility impairment | | | | | 1.75*** | (1.29–2.38) |
| ADL impairment | | | | | 1.99** | (1.25–3.18) |
| Model fit (log likelihood) | 2,702.44 | | 2,666.26 | | 2,454.02 | |

*Notes*: The 95% confidence interval (CI) is given in parentheses. Data in this table are weighted and adjusted for the complex survey design. The source of the data is the Asset and Health Dynamics Among the Oldest Old survey (1995 and 1998). The reference category for race is White; that for body weight is normal weight. OR = odds ratio; HH = household; ADL = activities of daily living.

*$p < .05$; **$p < .01$; ***$p < .001$.

mobility (OR = 1.75), or ADLs (OR = 1.99) are more likely to experience the onset of an upper body mobility impairment.

Table 5 presents results for the variables affecting the onset of ADL impairment. The factors that increase the likelihood of experiencing ADL impairment are being older and obese. Men and those with higher levels of education are less likely to experience ADL impairment.

Adding health behaviors in Model 2 shows that obese (vs. normal weight) respondents are still more likely to experience the onset of an ADL impairment. Furthermore, older adults who are current smokers or do not participate in exercise are more likely to experience the onset of impairment in ADLs.

Adding health conditions (Model 3) does affect body weight. The effect of obesity is partly explained with this inclusion. The full model indicates that having a greater number of serious conditions and symptoms and impairments in strength, lower body mobility, or upper body mobility are risk factors for the onset of impairment in ADL functioning.

To determine if the addition of each of the variable sets improves the models, I compared the model fit for each model across all four domains. Each subsequent model yields a statistically significant (at $p < .05$) improvement in model fit.

## Discussion

This project extends prior research by answering two broad research questions. Using a large nationally representative sample of older adults, findings show that body weight does have an influence on the onset of functional impairment over time. More specifically, they suggest that body weight is not only related to functional impairment among older adults in cross-sectional analyses as past research indicates (Himes, 2000), but it also predicts functional impairment over time. Second, findings show that health behaviors and health conditions do partially explain the relationship between body weight and the onset of various domains of impairment. Third, the findings provide initial insight into possible causal associations that may affect body weight and the onset of functional impairment. The interpretation of the specific mechanisms between body weight and the onset of functional impairment, however, should be made with caution. Body weight is measured at roughly the same time period as

Table 5. Results: Logistic Regression Models of the Onset of an ADL Impairment by Socioeconomic and Demographic Controls, Body Weight, Health Behaviors, and Health Conditions ($n$ = 3,373)

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | OR | CI | OR | CI | OR | CI |
| Socioeconomic and demographic controls | | | | | | |
| Age | 1.10*** | (1.07–1.12) | 1.09*** | (1.06–1.12) | 1.08*** | (1.05–1.11) |
| Male | 0.71* | (0.52–0.99) | 0.75 | (0.55–1.03) | 1.00 | (0.73–1.37) |
| African American | 1.05 | (0.73–1.50) | 1.02 | (0.71–1.47) | 1.00 | (0.66–1.53) |
| Latino | 0.62 | (0.33–1.14) | 0.58 | (0.31–1.08) | 0.71 | (0.39–1.29) |
| Married | 0.94 | (0.70–1.28) | 0.96 | (0.71–1.30) | 0.89 | (0.66–1.20) |
| HH income | 0.94 | (0.85–1.03) | 0.94 | (0.85–1.04) | 0.98 | (0.86–1.10) |
| Education | 0.94*** | (0.91–0.97) | 0.94*** | (0.91–0.97) | 0.96* | (0.92–0.99) |
| Body weight | | | | | | |
| Underweight | 0.67 | (0.35–1.28) | 0.60 | (0.31–1.16) | 0.58 | (0.30–1.12) |
| Overweight | 1.09 | (0.81–1.47) | 1.10 | (0.81–1.49) | 1.03 | (0.75–1.40) |
| Obese | 2.33*** | (1.59–3.42) | 2.24*** | (1.49–3.38) | 1.74** | (1.16–2.61) |
| Health behaviors | | | | | | |
| Binge drinker | | | 0.99 | (0.97–1.01) | 0.99 | (0.97–1.01) |
| Current smoker | | | 1.58* | (1.11–2.26) | 1.38 | (0.92–2.07) |
| Does not exercise | | | 1.68*** | (1.26–2.25) | 1.17 | (0.85–1.61) |
| Health conditions | | | | | | |
| Serious conditions | | | | | 1.14** | (1.04–1.25) |
| Symptoms | | | | | 1.15** | (1.04–1.26) |
| Strength limitations | | | | | 1.99*** | (1.34–2.94) |
| Lower body limitations | | | | | 1.99*** | (1.50–2.63) |
| Upper body limitations | | | | | 1.51** | (1.13–2.01) |
| Model fit (log likelihood) | 2,339.41 | | 2,314.09 | | 2,115.39 | |

*Notes*: The 95% confidence interval (CI) is given in parentheses. Data in this table are weighted and adjusted for the complex survey design. The Source of the data is the Asset and Health Dynamics Among the Oldest Old survey (1995 and 1998). The reference category for race is White; that for body weight is normal weight. OR = odds ratio; HH = household.

*$p$ < .05; **$p$ < .01; ***$p$ < .001.

health behaviors and health conditions. Therefore, it is difficult to determine which one precedes the other.

As expected, excessive weight does predict the onset of functional impairment and supports similar findings of cross-sectional analyses on older adults (Apovian et al., 2002; Himes, 2000). Obese older adults appear to be at particular risk for the onset of functional impairment. In the fully specified models, obesity was shown to contribute to impairments in strength, lower body mobility, and ADL impairment. This independent effect is likely the result of more physiological mechanisms that link obesity with an increased risk of functional impairment (Clark & Mungai, 1997; Hart & Spector, 1993; Walford et al., 1987).

This analysis also suggests that the relationship between body weight and the onset of functional impairment is complex. It appears that health conditions and health behaviors explain at least a portion of the relationship between body weight and the onset of functional impairment. More specifically, the one health behavior that seems to be a particular threat to functional impairment is lack of exercise. Older individuals who do not participate in regular vigorous physical activity are more likely to experience the onset of functional impairment. It may be that obesity restricts activity (Stewart & Brook, 1983) and, in turn, makes the protective effect of exercise on functioning less likely to be experienced.

As expected, health conditions are related to functional impairment. Individuals who have a greater number of serious conditions or symptoms or other functional impairments are more likely to become impaired. In addition, a consistent finding is that adding health conditions to the models reduces the effect of body weight (i.e., being overweight or obese) on functional impairment. This suggests that excess body weight increases the risk of functional impairment, but that it may partly be dependent on the effect of excess weight on chronic disease. This point is supported by other findings that suggest that body weight, particularly obesity, is a risk factor for various diseases such as heart disease, cancer, and stroke (Jousilahti et al., 1999; Must et al., 1999). Side effects and symptoms associated with those diseases can contribute to impairment (Verbrugge & Jette, 1994). Thus, without consideration of the effect of health conditions, the effect of obesity on the onset of functional impairment shown here may be an overestimation.

When further contemplating the meaning of these findings, one must consider the issue of sample selectivity. Healthier individuals overall, but particularly Latino and African American older adults, were likely selected into the AHEAD survey because of disparities in mortality. Latino and African American older adults have higher mortality rates (Buka, 2002; Schulz, Williams, Israel, & Lempert, 2002), in part because of obesity (Fontaine, Redden, Wang, Westfall, & Allison, 2003). As a result, they are less likely than White older adults to be age eligible for selection (70 years and older) into the AHEAD sample, suggesting that non-White obese respondents participating in the AHEAD survey are particularly robust. The implications are (a) that any association found here between obesity and the onset of impairment is likely to be a conservative estimate and (b) that the lack of evidence of racial disparities in the risk of the onset of functional impairment found herein may be attributed to a particularly healthy sample of Latino and African American older adults.

## Conclusions

Researchers examining functioning in the later years must be attentive to the complex relationships between body weight and the onset of impairment among older adults. Body weight is related to later life functioning, although it may work at least partly through both health behaviors and health conditions to influence the onset of functional impairment. However, these findings also suggest that, regardless of these other factors, excess weight contributes to the onset of functional impairment in some functional domains. Thus, interventions to encourage healthy weight maintenance and weight management are essential, especially for older minority populations. The development of effective interventions that target this health problem for a significant and growing number of older adults is vital to prevent or delay the onset of functional impairment in later life and thereby to improve the quality of life of the rapidly growing aging population.

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