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Impact of obesity and physical activity on functional outcomes in the elderly: Data from NHANES 2005–2010

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Abstract

Objectives—(1) to examine whether the association between obesity and physical functioning among older adults is moderated by physical activity; and (2) to test whether this moderating effect varies by gender.

Methods—Data from adults ≥60 who participated in the National Health and Nutrition Examination Surveys (2005–2010) were analyzed. Using multivariate logistic regression, we estimated the prevalence ratio of functional limitations and activities of daily living (ADL/IADL) impairment, by body mass index (BMI) and physical activity, while adjusting for age, educational level and a co-morbidity index.

Results—The sample included 5,304 subjects, mean age 70.4 years and 50.5% were female. Overweight and obesity was associated with higher levels of functional limitations when compared to normal weight individuals regardless of PA status (PR 1.47 (1.17–1.85) and 2.71 (2.00–3.67) even after adjustment for confounders.

Discussion—Overweight and obesity is associated with impairment in functional outcomes irrespective of physical activity.

Keywords

ADL; Impairment; Gender; Physical Function

Background

The prevalence of obesity in the US has increased exponentially during the last decades of the 20th century (“State-specific prevalence of obesity among adults--United States, 2005,” 2006). Recent results from the National Health and Nutrition Examination Survey indicate that the prevalence of overall obesity, as defined by body mass index (BMI) ≥ 30 kg/m2, was 30% or higher across most gender and ethnic groups of US adults, and was particularly prevalent among females (Flegal, Carroll, Kit, & Ogden, 2012; Ford, Li, Zhao, & Tsai, 2011; Ogden et al., 2006; Ogden, Carroll, & Flegal, 2003; “State-specific prevalence of obesity among adults--United States, 2005,” 2006). This high prevalence of obesity is now accompanied by an increasing older adult population in the US (Flegal, et al., 2012; Flegal, Carroll, Ogden, & Johnson, 2002), which makes it a public health priority to understand associations between obesity and aging-related health issues.

In addition to well-studied associations between obesity and many chronic health conditions, including hypertension, dyslipidemia (adverse lipid concentrations), and type 2 Diabetes (Nam, Kuo, Markides, & Al Snih, 2012; Newman et al., 2001; Seidell & Visscher, 2000), some previous studies have suggested a relationship between obesity and risk of limitations in physical functioning among the elderly (Alley & Chang, 2007; Stenholm et al., 2008; Stenholm et al., 2007; Wolinsky et al., 2011).

Overweight and obese individuals who are active and fit are reported to have lower mortality and morbidity rates than their normal weight counterparts who engage in sedentary behavior (Hawkins et al., 2009). Therefore, it is possible that physical activity may act as a moderator in the relationship between weight and late life functional impairment. The public health impact of functional impairments due to rising rates of obesity is expected to increase as the population ages (Chen & Guo, 2008; Hirvensalo, Rantanen, & Heikkinen, 2000; Koster et al., 2009). Understanding the extent to which physical activity can help to prevent such impairments could lead to important advances in public health efforts to promote healthy aging. Therefore, the objective of this study is twofold: (i) to examine whether the association between obesity and physical functioning among older adults is moderated by physical activity; and (ii) to test whether this moderating effect vary by gender.

Methods

The National Health and Nutrition Survey (NHANES) is a population-based survey designed to collect nationally representative data on health and nutrition, using a complex, multistage probability sample of the US civilian and non-institutionalized population. The survey includes an in-home interview on general health status, disease history, and diet and lifestyle, as well as a health examination at a mobile examination center (MEC). All participants provided written consent, and all interviews and examinations were carried out by trained technicians according to standard operation manuals (available at NHANES website: http://www.cdc.gov/nchs/nhanes.htm). In person interviews were conducted in either English or Spanish, using a computer-assisted personal interviewing system. Interview data were checked by NHANES field office staff for accuracy and completeness. The current study was limited to older participants (≥60 years) who participated in the MEC and completed the physical functioning section of the following NHANES surveys NHANES 2005–2006, NHANES 2007–2008, and NHANES 2009–2010 (n= 5379). All non-identified data (demographic questionnaire and examination files) were downloaded March 2013.

Functional outcomes

Two types of functional outcomes were assessed in this study—functional limitations (FL) and activities of daily living or instrumental activities of daily living (ADL/IADL) impairment. FL's were defined as inability or difficulty in performing the following tasks: walking several blocks, walking 1 block, sitting 2 hours, getting up from chair, climbing one flight of stairs, stooping, reaching with arms, pulling/pushing large objects, lifting weights and picking up a dime. Total scores ranged from 0–10 based on the total number of affirmative responses to having some difficulty, much difficulty, unable to do, do not do this activity. Those who answered refused and don't know, were not included in the analysis (n= 16). Participants were then classified as having FL if they reported at least one of the above limitations. Participants were classified as having ADL/IADL impairments if they reported any form of difficulty with at least one of the following: dressing, eating or getting out of bed, preparing meals, managing money or needing help with house or yard work. Similar to FL those who answered refused and don't know, were not included in the analysis (n= 7).

Covariates

For purposes of these analyses, we defined physical activity as the level of self-reported engagement in moderate or vigorous activity in a typical week. To determine PA level, survey participants were asked to review hand cards that listed examples of moderate and vigorous intensity PA. Moderate activity was defined as reporting one or more affirmative responses to gardening, cleaning the car, walking at a moderate pace, dancing or engaging in floor or stretching exercises. Vigorous activity was defined as having at least one affirmative response to running, jogging, swimming, cycling, aerobics, working out at the gym, playing tennis, or digging with a spade or shovel. Participants who answered yes to any of the vigorous and moderate activities were considered active. If they answered no to both categories they were considered inactive.

BMI was directly available from the household and mobile examination center interviews where it was collected by trained technicians. Weight was measured in pounds using a Toledo digital scale with the participant standing in the center of the scale facing the recorder, hands at their side, looking straight ahead. Height was assessed against a fixed stadiometer with a vertical backboard and a movable headboard. All participants were asked to keep their heels of both feet together, toes pointed slightly outward at approximately a 60° angle. BMI was categorized according to Centers for Disease Control and Prevention criteria (<18.5 kg/m^2, underweight; 18.5–24.9 kg/m^2, normal; 25.0–29.9 kg/m^2, overweight; and $\geq$ 30 kg/m^2, obese)(Center for Disease Control and Prevention, 2013).

A summary score was created as a measure of comorbidities using self-reported history of diabetes, hypertension, lung disease, stroke, any cancer, arthritis, myocardial infarction and chronic heart failure. These variables were coded as 0=no history and 1=positive history and then summed for a range comorbidity score of 0–8 (Batsis et al., 2013).

Race and ethnicity were assessed by self-report and subjects and were categorized as non-Hispanic white, non-Hispanic black, Mexican American, and other. Age was collected by self-report and modeled continuously in years. Self-reported education was categorized as grade less than 9, less than high school education, high school diploma or general education development (GED), some college, and more than college.

Analysis

To assess the potential relationship between study variables, we performed both simple and multivariate logistic regression analyses. First, bivariate analyses were conducted to examine the associations between obesity status and functional outcomes. Second, multivariate analyses were conducted to evaluate the independent effect of obesity on functional outcomes after adjustment for all potential confounding variables. Then to determine whether the obesity-functional outcome association differs between those who were and who were not physically active we repeated the logistic regressions with stratification for individuals who were active and non-active. Prevalence ratios (PR) of FL and ADL impairment and 95% confidence intervals (CI) were obtained from these models, adjusting for known potential confounders for functional outcomes including age, sex, education, physical activity, and comorbidities. These steps were then repeated for men and women separately. Analyses testing interaction terms between PA and gender, PA and BMI, and PA, BMI and gender showed none of the interaction tests to be statistically significant. For all analysis we used the appropriate sample weights, taking into consideration the unequal probabilities for selection as described in the NHANES website (http://www.cdc.gov/nchs/surveys.htm). All statistical analyses accounted for the different survey years, the complex survey design, and person-level analytic weights using SAS Survey software, version 9.2 (SAS Institute Inc., Cary, NC). Statistical tests were two-sided with *p*-values less than or equal to 0.05, or confidence intervals excluding 1.0, considered as statistically significant.

Results

The total study sample was 5,379, and participant characteristics, stratified by BMI category at baseline, are shown in Table 1. Overweight and obese participants were more likely than those with normal weight to be younger, less educated and to be married or living with a partner. They also had, on average, more chronic diseases and physical difficulties as measured by FL and ADL/IADL impairment. Overweight and obese participants were also more likely to be sedentary or report low levels of physical activity. Study subjects who were below-normal weight BMI <18.5 9 kg/m^2 (n=75) were excluded from the study because the number was too small for separate stratified analyses.

Table 2, provides the prevalence ratios for functional outcomes (both FL and ADL/IADL impairment), for the total sample and gender strata, in obese and overweight subjects compared to normal subjects. For the total sample, those who were obese have higher odds of FL even after adjusting for possible confounders (crude and adjusted PR for obese 2.44 (2.05–2.89) and 2.40 (1.97–2.92) respectively). Moreover, in the total sample, those who were obese had higher ADL/IADL impairments, but the association was not statistically significant after adjusting for potential confounder (see ADL/IADL impairment model 2). After stratifying by sex in the total sample, obese females had higher odds of functional limitations and ADL/IADL impairments compared to obese males. However, the BMI and gender interaction term was not significant. The adjusted PR for functional limitations among obese females was 3.08 (95% CI: 2.21–4.30), and 1.57 (95% CI: 1.22–2.01) for overweight females. The adjusted PR for impairment in ADL/IADLs was 1.40 (95% CI: 1.04–1.90) for obese females; whereas, overweight females had no significant difference in ADL/IADL impairment when compared to normal weight females. For obese males, the adjusted PR for FL was 1.59 (95% CI: 1.14–2.21), but there was no statistically significant difference for overweight when compared to normal weight males. For ADL/IADL impairment, neither obese nor overweight males were significantly different than normal weight males.

To further evaluate the association between obesity status and functional limitations and ADL/IADL impairment, we stratified the sample by physical activity (see table 3). In the total sample, having been overweight and/or obese was associated with higher levels of functional limitations when compared to normal weight individuals, regardless of PA status (total sample physically active adjusted PR 1.47 (1.17–1.85) and 2.71 (2.00–3.67) for overweight and obese, respectively). There were no statistically significant associations in the active total sample for ADL/IADL impairment. Following gender stratification, overweight and obese women who reported physical activity had a two and a fourfold increase in functional limitation after adjusting for potential confounders (overweight PR 1.82 (1.26–2.63); obese PR 3.96 (2.53–6.21)). Obese men who are physically active also had increased odds of functional limitations but not as high as women (PR 1.64 (1.06–2.54)). For ADL/IADL impairment, physical activity exerted a protective effect only among overweight men. The inactive group associations with functional limitations and ADL/IADL impairment were attenuated or did not show a consistent pattern across all measured stratums.

Discussion

In this study, we estimated the cross-sectional relationship between body mass index, physical activity and functional outcomes in a nationally representative sample of community dwelling older adults. Our study found a significant, positive relationship between obesity and functional outcomes in older adults, with a clearer pattern in higher prevalence odds of FL and ADL/IADL impairment among obese women. Our results further suggest that independent of PA level, obese subjects have a higher degree of limitations as compared to overweight/normal subjects. The strong association between high BMI and disability, particularly in women, seen in this study, with the risk of overall disability in the obese being four times greater than normal BMI women, suggests a strong sex effect. In obese men, the relationship between functional limitations and ADL impairment was not nearly as strong. Based on our results PA likely does not have a similar impact on disability among men and females.

Previous studies have shown that self-reported functional limitations increase with BMI (Armour, Courtney-Long, Campbell, & Wethington, 2012; Jenkins, 2004; Reynolds, Saito, & Crimmins, 2005). The Asset and Health Dynamics Among the Oldest Old survey found that obesity was associated with higher likelihood of functional impairment. Obesity had an independent effect on the onset of impairment in strength, lower body mobility, and activities of daily living (Jenkins, 2004). However, discrepant to our findings, they found physical activity to be a protective factor in reducing impaired physical functioning despite weight category, thus adding to the evidence suggesting that being physically active as an obese or overweight older adult is beneficial (Brach et al., 2003; Stenholm et al., 2010). Stenholm et al., 2007 in a Finnish population of predominately middle-aged adults, also examined the combined effects of BMI and fitness and found that being overweight and physically active provided protection against future disability among older adults. However, none of these studies presented data on the disability prevalence by sex.

The increased prevalence of FL associated with increasing BMI in women compared with men seen in this study may be attributable to a number of factors, including basic sex differences in disability, increased BMI may have a more disabling impact on women, or that in general men are more likely to recover from disabilities (Chen, Bermudez, & Tucker, 2002; Chen & Guo, 2008). In this study, obesity appears to be a stronger risk factor for physical functioning impairment among women as compared to men. Further, the negative impact of obesity in women was not attenuated by physical activity. However, one limitation of our study is the utilization of BMI as an indicator of body fat. For example, we are not certain if highly active women who are obese represent women with high amounts of body fat or if this is more representative of women with high amounts of lean tissue. A study that evaluates more than one measure of body weight reflecting both general and abdominal obesity may be better for determining overall prevalence of functional outcomes than a study with only one general measure of weight such as BMI. BMI accounts both for fat-free mass and general adiposity, and often is considered a suboptimal surrogate for adiposity (Romero-Corral et al., 2008). Finally, using BMI as a weight measure does not provide a direct measure of body fat amount and distribution, which may affect the risk of comorbities independent of BMI which can further lead to functional limitation.

Another possible explanation for our discrepant findings is perhaps that, normal weight, physically active women in our sample have a very low probability of impairment, while obese, physically active women had a disproportionately high probability of impairment. Still, the reason behind these sex differences in this study remains unclear and a possible direction for future work. Our findings suggest that the differences between men and women may reflect sex differences in the clinical pathways between increased BMI and functional outcomes which is certainly worth further exploring.

The primary limitation of this study is that the cross-sectional nature of NHANES does not allow drawing conclusions in terms of temporality, or the causal effects driving the relationship between BMI, PA and functional outcomes. Additionally, measures of functional outcomes vary in the degree of effort required of participants. Although we used ADL/IADLs which are the most commonly used outcome in studies of older adults NHANES does not have data in all the components of the IADLs/ADL. Therefore it can be that this type of measure may not be sensitive enough in the obese and overweight older adult and our results may underestimate observed effects. In addition, we are not able to determine whether limitation or impairment on functional outcomes predetermined sedentary lifestyles which in turn resulted in weight gain and obesity (reverse causality).

Our study has several strengths. We used a large national sample of the US elderly that includes different levels of physical activity and functional outcomes, which makes our findings more generalizable to community-dwelling U.S. elderly females and males. Further, the NHANES BMI measures were conducted by trained technicians according to standard procedures, and multiple measurements of functional outcomes were included in the analyses. In addition, different from other studies, we used two measures of functional outcomes to better ascertain the effect of PA and BMI categories.

Although based on our results PA does not moderate the effects of obesity. It is important to maintain PA from individual quality-of-life perspective because mobility difficulties have been found to predict further disability and loss of independence in older people (Hirvensalo, Rantanen, et al., 2000). This is highly relevant since regardless of weight limitations in physical functioning are reported to contribute to higher health care costs, and have implications for compromised quality of life and mortality in the already vulnerable older population(Cai, Lubitz, Flegal, & Pamuk, 2010). Further, a number of functional impairments are reported to be risk factors for subsequent disability and institutionalization (Cambois, Robine, & Romieu, 2005; Chen & Guo, 2008; Hirvensalo, Lintunen, & Rantanen, 2000). Therefore, our study's findings offer support for including maintenance of a healthy weight and physical activity in strategic planning for disability prevention and intervention.

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Table 1

Prevalence of Socio-Demographics and Health Related characteristics NHANES 2005–2010

Baseline Characteristics	**Total sample N=5304**	**Normal N=1339**	**Overweight N=1975**	**Obese N=1990**	***P for trend***
Mean age in years (SE)	70.4 (0.18)	71.8 (0.33)	70.6 (0.22)	69.0 (0.24)	N/A
Education N (%)					0.007
< 9 grade	1883 (35.6)	438 (32.9)	685 (34.7)	760 (38.2)	
High school	1288 (24.3)	316 (23.7)	494 (25.1)	478 (24.1)	
College or more	2120 (40.1)	578 (43.4)	793 (40.2)	749 (37.7)	
Race/ethnicity N (%)					<0.001
White	3006 (56.7)	806 (60.2)	1168 (59.2)	1032 (51.8)	
Black	1004 (18.9)	227 (17.0)	307 (15.6)	470 (24.1)	
Hispanic	1123 (21.2)	218 (16.3)	448 (22.7)	457 (23.0)	
Other	169 (3.2)	88 (6.5)	50 (2.5)	31 (1.6)	
Sex N (%)					<0.001
Female	2676 (50.5)	700 (52.3)	887 (45.0)	1089 (54.7)	
Marital status N (%)					N/A
Married or living with partner	3098 (58.4)	760 (56.7)	1186 (60.1)	1152 (57.8)	
Mean Comorbidity score (SE)	1.78 (0.03)	1.49 (0.04)	1.69 (0.03)	2.08 (0.06)	N/A
Physical activity N (%)					<0.001
No Physical activity	3223 (60.8)	759 (56.7)	1136 (57.7)	1328 (66.7)	
Functional Limitations N (%)					<0.001
FL	2927 (55.2)	623 (46.9)	997 (50.5)	1302 (65.4)	
Activities of daily living N (%)					<0.001
ADL/IADLs Impairment	1124 (21.2)	253 (18.9)	351 (17.8)	520 (26.1)	

Table 2

Prevalence Odds ratios (PR) and 95% confidence intervals of functional outcomes **and ADL/IADLs impairments** in relation to BMI categories **by gender**, NHANES 2005–2010

	Functional limitation	ADL/IADLs impairment
	PR (95% CI)	PR (95% CI)
Total sample		
Model 1[*]		
Normal	Reference	Reference
Overweight	1.27 (1.10–1.47)	0.96 (0.80–1.16)
Obese	2.44 (2.05–2.89)	1.46 (1.19–1.80)
Model 2[‡]		
Normal	Reference	Reference
Overweight	1.34 (1.13–1.59)	0.87 (0.70–1.08)
Obese	2.40 (1.97–2.92)	1.13 (0.91–1.39)
Female		
Model 1[*]		
Normal	Reference	Reference
Overweight	1.58 (1.26–1.98)	1.08 (0.81–1.44)
Obese	3.30 (2.57–4.24)	1.80 (1.36–2.40)
Model 2[‡]		
Normal	Reference	Reference
Overweight	1.57 (1.22–2.01)	1.00 (0.75–1.34)
Obese	3.08 (2.21–4.30)	1.40 (1.04–1.90)
Male		
Model 1[*]		
Normal	Reference	Reference
Overweight	1.08 (0.82–1.40)	0.82 (0.58–1.15)
Obese	1.78 (1.37–2.31)	1.07 (0.79–1.46)
Model 2[‡]		
Normal	Reference	Reference
Overweight	1.03 (0.77–1.36)	0.70 (0.49–1.01)
Obese	1.59 (1.14–2.21)	0.81 (0.58–1.13)

[*] Model 1 is unadjusted

[‡] Model 2 is adjusted for education, age, comorbidity and physical activity

Table 3

Prevalence ratios (PR) and 95% confidence intervals of functional limitation and **ADL/IADLs** impairment by **physical activity** categories **and gender**, NHANES 2005–2010

	Physically active		**Non active**	
	Functional limitation	**ADL/IADLs impairment**	**Functional limitation**	**ADL/IADLs impairment**
	PR (95% CI)	**PR (95% CI)**	**PR (95% CI)**	**PR (95% CI)**
Total sample				
Model 1*				
Normal	Reference	Reference	Reference	Reference
Overweight	**1.32 (1.05–1.64)**	0.95 (0.66–1.36)	**1.26 (1.00–1.58)**	0.96 (0.74–1.26)
Obese	**2.52 (1.85–3.43)**	1.38 (0.86–2.19)	**2.12 (1.74–2.58)**	**1.31 (1.01–1.69)**
Model 2≠				
Normal	Reference	Reference	Reference	Reference
Overweight	**1.47 (1.17–1.85)**	0.92 (0.64–1.34)	1.25 (0.97–1.62)	0.84 (0.62–1.13)
Obese	**2.71 (2.00–3.67)**	1.16 (0.77–1.74)	**1.99 (1.58–2.50)**	1.03 (0.79–1.34)
Women				
Model 1*				
Normal	Reference	Reference	Reference	Reference
Overweight	**1.74 (1.24–2.43)**	1.65 (0.94–2.89)	**1.43 (1.05–1.94)**	0.87 (0.63–1.20)
Obese	**4.13 (2.71–6.30)**	**2.39 (1.99–4.79)**	**2.48 (1.82–3.38)**	**1.40 (1.03–1.92)**
Model 2≠				
Normal	Reference	Reference	Reference	Reference
Overweight	**1.82 (1.26–2.63)**	**1.72 (1.01–2.93)**	1.374 (0.97–1.94)	0.77 (0.53–1.13)
Obese	**3.96 (2.53–6.21)**	1.86 (0.97–3.56)	**2.42 (1.65–3.56)**	1.16 (0.81–1.65)
Men				
Model 1*				
Normal	Reference	Reference	Reference	Reference
Overweight	1.06 (0.74–1.53)	**0.54 (0.32–0.93)**	1.13 (0.80–1.61)	1.08 (0.69–1.68)
Obese	**1.59 (1.04–2.44)**	0.73 (0.42–1.29)	**1.76 (1.23–2.52)**	1.17 (0.81–1.69)
Model 2≠				
Normal	Reference	Reference	Reference	Reference
Overweight	1.06 (0.75–1.49)	**0.49 (0.29–0.84)**	1.03 (0.69–1.55)	0.90 (0.56–1.46)
Obese	**1.64 (1.06–2.54)**	0.67 (0.41–1.06)	1.42 (0.91–2.23)	0.87 (0.59–1.28)

*Model 1 is unadjusted

≠Model 2 is adjusted for education, age and comorbidity