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Research Article

Cross-Sectional and Longitudinal Associations Between Adiposity and Walking Endurance in Adults Age 60–79

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Abstract

Background: The impact of excess weight on current and future walking endurance in nondisabled persons is unclear. This study examines the association between obesity and walking endurance among nondisabled persons both in late mid-life and early old age.
Methods: Participants in the Baltimore Longitudinal Study of Aging aged 60–79 years (n = 406) who reported no walking limitations, and completed a 400-meter walk "as quickly as possible" without lower-extremity pain, and had a follow-up assessment within 1.7–4.2 years. Adiposity was assessed by weight, body mass index (BMI), BMI category, and percent fat mass by DXA.
Results: Adjusting for age, sex, race, height, and physical activity, all adiposity measures were cross-sectionally associated with slower 400 meter time in both 60–69 and 70 to 79-year-olds (weight: β = 1.0 and 1.2; BMI: β = 2.8 and 3.6; and percent fat mass: β = 2.0 and 2.0, respectively, all $p < .001$). With additional adjustment for initial 400-meter performance and follow-up time, in 60- to 69-year-olds, change in 400-meter time (positive β indicates decline) was associated with all adiposity measures (weight: β = 0.4; BMI: β = 1.0; and percent fat mass: β = 0.5; all $p \le .05$) but not in the older group (weight: β = −0.4; BMI: β = −1.2; and percent fat mass: β = −0.2; all $p \ge .17$).
Conclusion: Excess weight and adiposity were associated with worse walking endurance in nondisabled persons aged 60–79 years and predicted accelerated decline in endurance in late mid-life adults. Weight management for mobility independence may be best targeted in obese persons approaching traditional retirement age.

Keywords: Obesity—Fitness—Older adults—Walking endurance

In the last decade, the prevalence of obesity has increased among older adults, reaching 36% in men and 42% in women (1,2). Obesity has been associated with increased risk of mobility decline and disability (3,4), which are important quality of life issues for older adults. This association between obesity and mobility is often found in conjunction with, and frequently explained by, impairments such as low muscle strength, lower extremity pain, and limited physical function (5,6). There is a general impression that as long as one has no functional limitations, then having excess weight has no health or functional consequences. Whether obesity compromises walking ability in older adults with no discernable impairments is unclear.

Further, much of the work on mobility and obesity among the aged has focused on persons over 70 years of age. Since weight loss may be related to increased health risks in more advanced age, the impact of adiposity during late middle-age should be evaluated because weight management may be less risky and interventions more effective during that phase of life. To better clarify the relationship between obesity and mobility at the transition from late middle age to old age, we examined the association between several measures of adiposity and walking endurance in functionally independent persons aged 60–79 years in the Baltimore Longitudinal Study of Aging (BLSA). Because self-reported mobility capacity may underestimate prevalent mobility difficulties, especially in obese individuals, walking endurance, and endurance declines were assessed objectively using performance on a 400-meter walk done "as quickly as possible" (7). Additionally, objective measures such as the 400-meter walk have been shown to predict future limitations and disability (8).

Methods

Study Population

The study population consists of participants in the BLSA aged 60–79 years, who were eligible for and completed the 400-meter walk without the use of a walking aid. To take part in the 400-meter walk, participants needed to be free of severe electrocardiogram abnormalities and acutely elevated blood pressure; and in the prior 3 months, deny having a myocardial infarction, angioplasty, or heart surgery, as well as no new or worsening symptoms of chest pain, shortness of breath, or angina. They also had to complete a 2.5-minute usual pace walk without difficulty or symptoms. Additionally, to limit the influence of pain, impaired strength, functional limitations, and possible frailty, we also excluded participants with pain reported during the initial 400-meter walk, low grip strength (men < 26 kg and women < 16 kg) (9), poor physical performance (Short Physical Performance Battery score < 9) (6,10), or a body mass index (BMI) of 18.5 or lower (11). Finally, participants were required to have a follow-up visit within 21–51 months of the initial eligible visit. Applying these criteria yielded a study population of 406 men and women of whom 213 were aged 60–69 years. Further detail is provided in Table 1.

Data were collected between April 2007 when the 400-meter walk was introduced into the BLSA and March 2015, the most recently available follow-up data. The BLSA constitutes a continuous enrollment cohort study of normative aging conducted by the National Institute on Aging, Intramural Research Program, with enrollment at the initial visit restricted to persons free of cognitive impairment, functional limitations, chronic diseases, and cancer within the past 10 years. Participants receive regularly scheduled comprehensive health, cognitive, and functional evaluations conducted over a 3-day visit to the National Institute on Aging-Intramural Research Program clinic facility. By design, follow-up visits occur every 2 years for persons aged 60–79 and annually for persons aged 80 and older. The BLSA protocol was approved by the standing Institutional Review Board of either Medstar Research or the National Institute of Environmental Health Sciences depending on the date of data collection. All participants provided informed consent.

Measures

Adiposity

Standardized procedures were used to measure height (cm) and weight (kg). BMI was calculated in kg/m^2 and overweight was defined as BMI 25.0–29.9 and obesity defined as BMI ≥ 30 (12). Fat mass was calculated using Dual-energy X-ray absorptiometry (model DPX-L Lunar Radiation, Madison, WI) and expressed as a percentage of overall body mass.

Walking endurance

Walking endurance was assessed using the 400-meter walk component of the Long Distance Corridor Walk, a self-paced assessment of walking endurance. Participants were asked to walk "as fast as possible, at a pace you can sustain for 400 meters." Standardized encouragement was provided for each lap and the total time to walk 400 meters was recorded. It was noted whether a walking aid was used at the time of testing, and at the conclusion of the test,

Table 1. Participant Characteristics

	Total	60–69 years	70–79 years	
	n = 406	*n* = 213	*n* = 193	
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	*p*
Age, y	68.4 (5.6)	63.6 (2.8)	73.6 (2.7)	<.001
Female, *n* (%)	206 (50.7)	123 (57.8)	83 (43.0)	.003
Black, *n* (%)	132 (32.5)	77 (36.2)	55 (28.5)	.10
Height, cm	169.2 (9.1)	169.0 (9.0)	169.5 (9.3)	.56
Grip strength, kg	33.5 (9.8)	34.0 (10.0)	33.0 (9.6)	.31
Short Physical Performance Battery	11.7 (0.7)	11.8 (0.7)	11.6 (0.8)	.01
Physical activity, *n* (%)				.99
≤30 min/wk	106 (26.1)	56 (26.3)	50 (25.9)	
31–149 min/wk	123 (30.0)	65 (30.5)	58 (30.1)	
≥150 min/wk	177 (43.6)	92 (43.2)	85 (44.0)	
Adiposity				
Weight, kg	78.1 (15.9)	80.3 (16.4)	75.6 (15.0)	.003
BMI, kg/m^2	27.2 (4.6)	28.0 (4.9)	26.2 (3.9)	<.001
BMI classifications, *n* (%)				<.001
Normal, 18.5–24.9	143 (35.2)	62 (29.1)	81 (42.0)	
Overweight, 25–29.9	165 (40.6)	83 (39.0)	82 (42.5)	
Obese, ≥30	98 (24.1)	68 (31.9)	30 (15.5)	
Fat mass, %	34.7 (8.7)	36.2 (8.9)	33.0 (8.1)	<.001
Walking endurance				
Initial 400 m, s	259.5 (38.4)	251.3(35.1)	266.3(38.3)	<.001
Follow-up 400 m, s	269.6 (54.2)	257.7(39.6)	279.4(63.5)	<.001
Meaningful decline, *n* (%)	155 (38.2)	65 (30.5)	90 (46.6)	<.001

Notes: BMI = body mass index. Smoker indicates current smoker or quit in the last 10 years. Meaningful decline indicates one of the following: a follow-up 400-meter walk time at least 5% slower than initial time, an alternative type follow-up visit (eg, a home visit or phone interview only) due to declining health, meeting test exclusion criteria for health reasons, or being unable to complete the full 400-meter walk.

participants were asked if they experienced any pain in their feet, calves, knees, hips, or back during the walk. Validity of test performance has been demonstrated against peak oxygen consumption during a treadmill test (13).

Covariates

Demographic characteristics included age, sex, and self-identified race, which were categorized as black or non-black. Physical activity was self-reported using a standardized questionnaire and categorized as ≤30, 31–149, or ≥150 minutes of moderate to vigorous physical activity per week (14–16). Physical activity level was included as a covariate, as obese older adults who are also physically active have been found to have no greater risk of developing mobility limitations than their nonobese counterparts (17).

Statistical Analyses

Regression analyses were used to examine the cross-sectional association between each adiposity measure (weight, BMI, BMI classification, and percent fat mass) and performance on the 400-meter walk controlling for age, sex, race (black or nonblack), height (only for weight and percent fat mass) and physical activity, separately for 60- to 69-year-olds and 70- to 79-year-olds. Similar regression analyses examined the association of adiposity with change in 400-meter performance accounting for initial 400-meter time and follow-up time in addition to the other covariates. Change in 400-meter walk time was calculated as follow-up time minus initial time such that a positive value indicates decline.

Additionally, to assess potential informative censoring, we performed a sensitivity analysis that included persons who did not have a follow-up 400-meter time due to health-related problems. For this analysis, we used logistic regression to examine the association of adiposity with the likelihood of experiencing a "meaningful performance decline." We defined four categories of decline: having a follow-up 400-meter walk time at least 5% slower than initial time (18,19); having an alternative type follow-up visit (eg, a home visit or phone interview only) due to declining health; meeting test exclusion criteria; or being unable to complete the full 400-meter walk. The logistic regression controlled for age, sex, race (black or nonblack), physical activity, height (only for weight and percent fat mass), initial performance, and follow-up time. Analyses were conducted using SAS version 9.2 (SAS Institute, Inc., Cary, NC).

Results

The basic characteristics of the 213 participants aged 60–69 years and 193 participants aged 70–79 years at their initial eligible visit are shown in Table 1. Less than 3% of the sample reported currently smoking or quitting in the last 10 years. All but two participants graduated from high school and 84% graduated from college. The 70- to 79-year-old participants had lower BMI (26.2 vs 28.1, $p < .001$), a lower proportion of participants with a BMI over 30 (15.5 vs 31.9, $p < .001$), and lower percent fat mass (33.0 vs 36.2, $p < .001$) compared with the 60- to 69-year-old participants. They also had poorer 400-meter walk performance at the initial 400-meter walk ($p < .001$). On average, both 60-year-old (mean = 6.8, SD = 20.6, $p < .001$) and the 70-year-old (mean = 15.3, SD = 41.2, $p < .001$) participants needed significantly more time to walk 400 meters quickly at follow-up, a little over 2 years later.

The cross-sectional association between adiposity and walking endurance is presented in Table 2. In both, those aged 60–69 and

Table 2. Association Between Adiposity and Walking Endurance

	Weight	BMI	BMI Classifications	Percent Fat Mass
	β (*p*)	β (*p*)	β (*p*)	β (*p*)
	Age 60–69 y (*n* = 213)			
Age, y	3.8 (<.001)	3.9 (<.001)	4.0 (<.001)	3.3 (<.001)
Female	22.1 (<.001)	28.2 (<.001)	27.3 (<.001)	−2.3 (.69)
Black	6.6 (.09)	6.8 (.08)	9.0 (.02)	9.2 (.01)
Weight, kg	1.0 (<.001)	—	—	—
BMI, kg/m²	—	2.8 (<.001)	—	—
BMI classifications				
Normal, 18.5–24.5	—	—	Reference	—
Overweight, 25–29.5	—	—	9.6 (.03)	—
Obese, ≥30	—	—	30.7 (<.001)	—
Fat mass, %	—	—	—	2.0 (<.001)
	Age 70–79 y, (*n* = 193)			
Age, y	3.2 (<.001)	3.3 (<.001)	3.0 (<.001)	2.6 (.002)
Female	21.1 (.002)	26.7 (<.001)	26.4 (<.001)	−5.6 (.42)
Black	7.6 (.16)	6.5 (.23)	7.7 (.16)	10.6 (.05)
Weight, kg	1.2 (<.001)	—	—	—
BMI, kg/m²	—	3.6 (<.001)	—	—
BMI classifications				
Normal, 18.5–24.9	—	—	Reference	—
Overweight, 25–29.9	—	—	17.2 (.002)	—
Obese, ≥30	—	—	35.3 (<.001)	—
Fat mass, %	—	—	—	2.0 (<.001)

Notes: BMI = body mass index. Regression equations were performed individually for each adiposity-age group combination. All equations were adjusted for age, sex, race (black vs nonblack), height (only for weight and percent fat mass), and physical activity.

70–79 years, higher weight, BMI, BMI category, and percent fat mass were associated with poorer walking endurance as reflected in slower 400-meter walk time with greater adiposity.

Table 3 displays the association among the adiposity measures and change over time in walking endurance. All but three of the 60-year-olds were able to complete the 400-meter walk at their follow-up visit, and among this group, higher weight, BMI, and percent fat mass were associated with larger declines in walking endurance. Obesity, but not overweight also predicted performance decline. Among the 70-year-olds, all but 10 were able to complete the 400-meter walk. In contrast to the 60-year-olds, none of the adiposity measures were associated with walking endurance decline. No sex–adiposity interactions were found in the cross-sectional or longitudinal analyses.

To account for potential informative censoring, we performed sensitivity analyses where meaningful decline was dichotomized and included those unable to complete the test, ineligible due to health problems and those who required a home or phone visit due to poor health. Results were similar; in 60-year-olds, 30.5% had a decline in walking endurance. Odds ratios and (95% confidence intervals) associated with decline for each additional unit of weight, BMI, and percent fat mass were respectively, 1.05 (1.02–1.08), 1.13 (1.05–1.23), and 1.07 (1.01–1.12) (all $p < .02$). Among 70-year-olds, 46.6% exhibited meaningful decline, and none of the odds ratios were significant 1.01 (0.97–1.04), 1.01 (0.92–1.10), and 1.01 (0.96–1.06).

Discussion

Persons aged 60–79 years with no functional limitations or walking-related lower body pain have increasingly worse endurance-related function with increasingly greater weight and/or fat, regardless of physical activity level. Using the beta coefficients from the regression analyses to interpret these findings, it appears that three additional kilograms of weight or one additional unit of BMI is equivalent to the impact of an additional year of age on poorer endurance capacity. Further, among those in their sixties, this excess weight and/or body fat predicts both greater loss and a higher likelihood of meaningful decline in walking endurance. Importantly, upwards of 30% and 46%, respectively, of relatively high-functioning 60- and 70-year-olds experienced meaningful decline in walking endurance in just over 2 years. Although a similar magnitude of decline has been observed previously (14,20), the contribution of adiposity, especially in adults near traditional retirement age, with no overt impairments, has been underappreciated.

Although several studies document the higher prevalence of mobility difficulties in obese older adults, few have quantified the associated deficit. In a sample of 79 persons aged 55–84 (mean = 63.6) with symptomatic knee osteoarthritis, both overweight and obese persons walked 400 meters about 29 seconds more slowly than normal weight persons (21). This is similar to the findings in 60- to 69-year-olds in the present study, where lower aerobic fitness was indicated by an additional 10 and 31 seconds needed to walk 400 meter quickly for persons who are respectively overweight or obese relative to normal weight. Although not completely analogous, data from the Aerobic Center Longitudinal Study on persons aged 60 years and older show that mean BMI and percent fat mass are higher with increasingly lower cardiorespiratory fitness (22).

Studies examining the association between adiposity and change in endurance walk capacity or fitness are equally rare. Although several have found obesity and other measures of adiposity associated with

Table 3. Association Between Adiposity and Change in Walking Endurance

	Weight	BMI	BMI Classification	Percent Fat Mass
	β (*p*)	β (*p*)	β (*p*)	β (*p*)
	Age 60–69 y, (*n* = 210)			
Age, y	1.5 (.007)	1.5 (.007)	1.4 (.01)	1.3 (.02)
Female	0.5 (.91)	2.2 (.49)	1.1 (.74)	−6.5 (.18)
Black	1.6 (.61)	1.7 (.58)	3.0 (.35)	3.3 (.29)
Weight, kg	0.4 (.003)	—	—	—
BMI, kg/m²	—	1.0 (.004)	—	—
BMI classifications				
Normal, 18.5–24.5	—	—	Reference	—
Overweight, 25–29.5	—	—	2.7 (.45)	—
Obese, ≥30	—	—	7.9 (.07)	—
Fat mass, %	—	—	—	0.5 (.04)
	Age 70–79 y, (*n* = 183)			
Age, y	−0.1 (.99)	−0.1 (.93)	0.1 (.95)	0.1 (.91)
Female	−2.5 (.77)	−5.0 (.48)	−4.9 (.50)	2.6 (.77)
Black	8.3 (.23)	8.7 (.21)	8.1 (.24)	7.4 (.28)
Weight, kg	−0.4 (.21)	—	—	—
BMI, kg/m²	—	−1.2 (.17)	—	—
BMI classifications				
Normal, 18.5–24.9	—	—	Reference	—
Overweight, 25–29.9	—	—	−7.5 (.28)	—
Obese, ≥ 30	—	—	−10.2 (.32)	—
Fat mass, %	—	—	—	−0.2 (.74)

Notes: BMI = body mass index. Regression equations were performed individually for each adiposity-age group combination. Walking endurance declines were calculated as follow-up—initial. All equations were adjusted for age, sex, race (black vs nonblack), height (only for weight and percent fat mass), physical activity, initial 400-meter performance and time to follow-up.

increased risk of developing mobility limitation (23–25), most did not account for the likely already diminished baseline capacity among the obese, as the cross-sectional findings from this study demonstrate. Thus, the lack of association between baseline adiposity and mobility declines in 70- to 79-year-olds observed in the current work may reflect consideration of baseline performance in the modeling. Nevertheless, this finding contrasts with results from a study of decline in usual gait speed over 4 years among over 2,200 persons in their seventies. The study accounted for baseline gait speed and found weight, BMI, and percent fat mass were associated with decline, especially in women (26). However, that study used broad categories rather than continuous measures for weight, BMI, and percent fat mass. It is important to note that among the 70-year-olds in our study, higher adiposity was associated with lower capacity, just not accelerated decline.

In contrast, adiposity was associated with poor initial walking endurance and accelerated decline in the 60-year-old group. In fact 30% of this high functioning group had meaningful decline in walking endurance during follow-up, which averaged only 2.3 years. Although this finding is consistent with Beavers' work (26), it extends the observation to persons in late mid-life and to fitness assessment.

The strengths of these analyses are the inclusion of 60-year-olds and the use of an objective test of walking endurance, allowing us to better assess preclinical declines in this high functioning group. Screening of participants also included physical assessment of both muscle strength and physical functioning providing a rigorous selection process. Additional strengths of the study include diversity in both sex and race. Finally, the meaningful decline analyses addressed potential informed missingness and supported the primary findings. Limitations include the generally healthy study sample that may restrict generalization. Moreover, future analyses should consider whether obesity in and of itself or whether specific obesity-related conditions contribute to endurance walk decline in high functioning 60-year-olds. Examination among specific subgroups may help in developing targeted interventions to reduce decline.

Although excess adiposity in older adults may not confer the same morbidity risk as it does for younger adults (4), the results of this study indicate that in persons approaching or entering retirement, who have no overt functional impairments, excess adiposity may negatively impact current and future endurance capacity and fitness. There is increasing evidence that weight loss, independent of physical activity, can improve physical function in older adults (3). Even high-functioning older adults, especially those in their 60s, may benefit from weight loss efforts. Based on findings that midlife obesity is associated with declining function in older adults (27), early interventions may help maintain physical function in later years.

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Conflict of Interest

Three of the authors (E.M.S., S.A.S., L.F.) are associate editors of this publication.

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