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ORIGINAL ARTICLE

The association between weight history and physical performance in the Health, Aging and Body Composition study

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Objective: Although the association between current obesity and physical disability is well known, the cumulative effect of obesity is unknown. Using data from the Health, Aging and Body Composition study, we examined the association between weight history in young and middle adulthood and weight status in late adulthood with physical performance in late adulthood.
Design: Longitudinal cohort study.
Subjects: White and black men and women aged 70–79 years at study baseline ($n = 2803$).
Measures: Body mass index (BMI; kg/m^2) was calculated using recalled height at age 25 and weight at age 25 and 50 and measured height and weight at ages 70–79. Physical performance at ages 70–79 was assessed using a short physical performance battery (SPPB) and a 400-m walk test.
Results: In this well-functioning cohort, approximately 24% of men and 8% of women reported being overweight or obese (BMI $\geqslant$25 kg/m^2) at age 25, 51% of men and 37% of women reported being overweight or obese at age 50, and 69% of men and 66% of women were overweight or obese at ages 70–79. Men and women who were obese (BMI $\geqslant$30 kg/m^2) at ages 25, 50 and 70–79 had significantly worse SPPB scores and 400-m walk times than those who were normal weight. Women who were overweight (BMI 25–29.9 kg/m^2) at ages 25, 50 and 70–79 also had significantly worse physical performance. Furthermore, men and women who had a history of being overweight or obese at ages 25 or 50 had worse physical performance compared to those who were normal weight throughout or who were overweight or obese at ages 70–79 but not in midlife or earlier.
Conclusions: Maintaining a healthy body weight throughout adulthood may play a role in preventing or delaying the onset of physical disability.
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Keywords: BMI; aging; physical performance; physical function

Introduction

The elderly US population is growing and is expected to double by the year 2030 to approximately 20%.[1] In addition, US adults are, on average, increasingly heavier at every age studied with approximately one-fourth of young adults and one-third of middle-aged and older adults classified as obese (body mass index (BMI) $\geqslant$30 kg/m^2).[2] It is well known that obesity increases the risk of cardiovascular disease, several cancers, diabetes, as well as other chronic conditions.[3,4] Obesity in middle-aged and older adults has also been shown to increase the risk of physical disability,[5–10] possibly as a result of these chronic conditions or by other mechanisms. Some have suggested that the growing prevalence of obesity, particularly among younger age groups, could reverse the

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recent declines in disability rates among future generations of elderly as well as contribute to increasing disability rates among middle-aged and younger adults.[11,12]

Although the association between obesity in middle and late adulthood and physical disability is well documented,[5–10] few studies have examined the impact of obesity among younger adults or the cumulative effect of obesity from young to late adulthood on physical disability later in life.[13–15] In the National Health and Nutrition Examination Survey, recalled weights at ages 25 and 40 were significantly correlated with self-reported physical disability in men and women aged 60–87.[13] Obesity from recalled weight at age 25 was also associated with self-reported functional limitations and disability among white and black men and women aged 52–75 in the Atherosclerosis Risk in Communities Study.[15] Less is known about the role of obesity on objectively measured physical performance in late adulthood.[16–19] Thus, the objective of this study was to examine the association between weight history in young and middle adulthood and weight in late adulthood with physical performance in men and women aged 70–79. The association between weight history across all three time points and physical performance was also examined.

Methods

Study population

Data for this analysis are from the Health, Aging and Body Composition (Health ABC) study; a prospective cohort study investigating the associations between body composition, weight-related health conditions and incident functional limitations in older adults. The Health ABC study enrolled 3075 community-dwelling black and white men and women aged 70–79 between April 1997 and June 1998. Participants were recruited from a random sample of white and all black Medicare eligible residents in the Pittsburgh, PA and Memphis, TN, metropolitan areas. Participants were eligible if they reported no difficulty in walking one-fourth of a mile, climbing up 10 steps or performing basic activities of daily living (ADLs), were free of life-threatening illness, planned to remain in the geographic area for at least 3 years, and were not enrolled in lifestyle intervention trials. All participants provided written informed consent and all protocols were approved by the institutional review boards at both study sites.

Participants, who were missing recalled weight at age 25 ($n=75$) or 50 ($n=63$) or recalled height at age 25 ($n=44$) and participants who were underweight (BMI $<18.5\,kg/m^2$) at study baseline (ages 70–79; $n=35$), were excluded. Participants who were missing the Health ABC short physical performance battery (SPPB) ($n=35$) and other pertinent covariates ($n=20$) were also excluded. The final analysis sample was 2803 participants. For the 400-m walk, an additional 345 participants were excluded based on the exclusion criteria for the Long Distance Corridor Walk and another 320 did not complete the walk.

Physical function

A SPPB modified from the lower-extremity performance tests used in the Established Populations for the Epidemiologic Studies of the Elderly (EPESE)[20] was used to summarize lower extremity physical performance. The Health ABC SPPB consisted of five repeated chair stands, standing balance (semi- and full-tandem stands and a single leg stand for 30 s), a 6-m walk to assess usual gait speed, and a narrow 6-m walk test of balance (walking at usual pace within lines of tape spaced 20 cm apart). The scoring system for the Health ABC SPPB was developed to minimize ceiling effects and has previously been described.[21] The Health ABC SPPB scores are continuous and range from 0 to 4, with higher scores indicative of better performance.

Walking endurance was measured using the Long Distance Corridor Walk.[21] The course was 20-m long marked by cones at each end. The first part consisted of a 2-minute warm-up walk in which participants were instructed to 'cover as much ground as possible'. The second part consisted of a 400-m walk; participants were instructed to 'walk as quickly as possible at a pace you can maintain' and time to complete the 400-m walk was recorded. Heart rate was monitored continuously using the Polar Pacer (Model No. 61190; Woodbury, NY, USA). Participants were excluded from the 400-m walk if they had potentially acute electrocardiography abnormalities, elevated blood pressure ($\geqslant$200/110 mm Hg), resting heart rate <40 or >120 beats per minute (b.p.m.), reported a recent cardiac event or procedure, or reported new or recent worsening cardiac symptoms.[21] The walking endurance test was terminated by the staff if the participant's heart rate exceeded 135 b.p.m. or by the participant if unable to continue because of pain, fatigue or any other symptom.

Weight history

At the baseline visit, participants were asked to recall their usual body weight at age 25 (women were instructed to answer for a time when not pregnant) and age 50, as well as recall their height (without shoes) at age 25. Weight at the study baseline (ages 70–79) was measured in kilograms using a standard balance beam scale and height was measured in millimeters using a Harpenden stadiometer (Holtain Ltd, Crosswell, UK). BMI (kg/m^2) at age 25 and 50 was calculated using recalled weight at age 25 or 50 and recalled height at age 25, while BMI at study baseline (ages 70–79) was calculated using measured weight and height. BMI was categorized using standard National Institute of Health (NIH) cut-points (underweight: BMI $<18.5\,kg/m^2$; normal weight: BMI 18.5–24.9 kg/m^2; overweight: BMI 25.0–29.9 kg/m^2; obese: BMI $\geqslant 30.0\,kg/m^2$).[22] For BMI status at age 25 and 50, underweight participants ($n=232$ at age 25; $n=46$ at age 50) were included with normal weight. Additional analyses that excluded underweight participants at ages 25 and 50 were similar to those that included them with the normal weight group (data not shown). To assess weight history across all three time points, the following categories were created: normal weight at age 25, 50 and ages 70–79; overweight and/or obese at ages 70–79 but not at age 25 or 50; overweight and/or obese at ages 70–79 and age 50 but not at age 25; overweight and/or obese at all three time points; and overweight and/or obese at age 50 but not at ages 70–79; with other weight history patterns categorized as other. For the weight history analyses, recalled height at age 25 was used to calculate BMI at study baseline (ages 70–79) in addition to BMI at ages 25 and 50 to minimize possible misclassification bias owing to systematic differences between recalled height at age 25 and measured height at study baseline. Results were similar when measured height at study baseline was used to calculate BMI at ages 25 and 50 and study baseline (data not shown).

Potential confounders
Demographic characteristics (age, gender, race and education), smoking status and physical activity were ascertained by an interviewer-administered questionnaire at study baseline. The time and intensity of physical activity performed in the past 7 days, including walking for exercise, other walking, climbing stairs, aerobic dance, weight training, and other high and medium intensity activities, were summed (kcal/week). As weight history may affect physical performance as a consequence of weight-related health conditions, prevalent health conditions were examined as potential mediators of the associations. The prevalence of diabetes, coronary heart disease, congestive heart failure, stroke, chronic obstructive pulmonary disease, knee pain and depression were determined using algorithms based on self-report and medication use at study baseline and participants with definitive health conditions were coded as 'yes'. The Modified Mini-Mental State Examination (3MS) was used as an indicator of general cognitive status with a minimum score of zero and maximum score of 100 (best).[23] As mean scores on the 3MS vary by education, a cut-point of <75 for individuals with less than a high school education and a cut-point of <80 for individuals with a high school education were used to classify participants as cognitively impaired.

Statistical analyses
Multiple linear regression models were used to examine the associations between BMI status at age 25, 50 and study baseline (ages 70–79) and physical performance measures (SAS PROC GENMOD) using SAS version 8.2. (SAS Institute, Cary, NC, USA) and least-squares means reported. Two-way interactions between gender and BMI status at ages 25, 50 and study baseline (ages 70–79) were tested and interactions were found at the significance level $\alpha = 0.10$. Interactions between race and BMI status at ages 25, 50 and study baseline (ages 70–79) within gender group were also tested but were not significant. In analyses stratified by gender and race, results for blacks and whites were similar within gender groups. Thus, all analyses are presented in men and women separately with race groups combined. Models were adjusted for age, race, field center, education, smoking status and physical activity at study baseline. Additional models were also adjusted for prevalent health conditions at study baseline. The association between a history of overweight and/or obesity across all three time points vs maintenance of normal weight and physical performance was also examined.

Results

The mean age of the study population was 73.6 years, 50% were women, and 40% were black. Participants who were excluded were more likely to be female, black, and older and have less than a high school education. However, the mean BMI of excluded participants was not different from those who were included in the analysis sample. Compared to those who were included in the analysis sample, participants who were excluded had worse SPPB scores (1.91 vs 2.20, $P<0.0001$), were less likely to complete the 400-m walk (66 vs 76%, $P<0.01$), and had worse 400-m walk times (356.5 vs 329.9s, $P<0.0001$). The descriptive characteristics of the study population by gender are shown in Table 1. Men were more likely to have greater than a high school education and a smoking history than women. Approximately 42% of men and 60% of women reported less than 500 kcals/week from walking and exercise.

Table 1 Participant characteristics (means±s.d. or frequencies) at study baseline (ages 70–79) in men and women: the Health ABC study

	Men (n = *1387*)	*Women* (n = *1416*)
Age, years	73.7±2.9	73.4±2.8
Black race	35.4	43.9
Education		
<High school	26.3	21.2
High school graduate	25.2	40.2
>High school	48.4	38.6
Smoking status		
Never	29.7	57.3
Current	10.3	8.8
Former	60.0	33.9
Physical activity		
<500 kcal/week	41.7	60.2
500–<1500 kcal/week	28.4	27.0
⩾1500 kcal/week	29.8	12.7
Prevalent chronic conditions		
Diabetes	15.9	12.9
Stroke	6.7	7.8
Coronary heart disease	22.2	11.6
Congestive heart failure	1.8	0.9
Chronic obstructive pulmonary disease	11.8	11.4
Knee pain	14.1	18.3
Depression	3.8	5.5
Cognitive impairment	8.2	5.5

Abbreviations: Health ABC study, Health, Aging and Body Composition study.

The prevalence of overweight or obesity (BMI $\geqslant 25\,kg/m^2$) in men was approximately 24, 51 and 69% at age 25, 50 and study baseline (ages 70–79), respectively (Figure 1). In women, the prevalence of overweight or obesity was approximately 8, 37 and 66%, respectively. Approximately 31% of men and 38% of women were normal weight at all three time points, while 18% of men and 7% of women were overweight or obese at all three time points. The prevalence of overweight or obesity at both age 50 and study baseline (ages 70–79) was similar in men and women, 23 and 27% respectively; however, 16% of men and 24% of women were overweight or obese at study baseline but not at ages 25 or 50.

The adjusted mean physical performance measures by weight status at ages 25, 50 and study baseline (ages 70–79) for men and women are shown in Table 2. SPPB scores in men who were overweight or obese at age 25 were significantly lower and 400-m walk times in men who were obese at age 25 were significantly slower compared to those who were normal weight ($P<0.05$). In women, those who were overweight at age 25 had significantly lower SPPB scores, while those who were obese had significantly slower 400-m walk times compared to those who were normal weight ($P<0.05$). Although women who were obese at age 25 also had lower SPPB scores, they were not significantly different from those of normal weight women. Men and women who were obese at age 50 or at study baseline (ages 70–79) had significantly lower SPPB scores and slower 400-m walk times compared to those who were normal weight or overweight ($P<0.05$). The SPPB scores were also significantly lower among women who were overweight at age 50 or at study baseline (ages 70–79) compared to those who were normal weight ($P<0.05$). Four hundred-meter walk times in men and women who were overweight at age 50 and in women who were overweight at study baseline (ages 70–79) were also significantly slower compared to those who were normal weight ($P<0.05$). The associations between weight status at study baseline (ages 70–79) and physical performance measures were similar when recalled height at age 25 was used in place of measured height at study baseline (data not shown). Adjusting for prevalent health conditions at baseline attenuated the associations between weight status at ages 25, 50 and study baseline (ages 70–79) and physical performance slightly, but in general, the associations remained significant. Further adjustment for BMI at study baseline (ages 70–79) attenuated the associations between weight status at ages 25 and 50 and physical performance (data not shown), however, with the exception of weight status at age 25 in women, the trends remained similar. Approximately 12% of men and 13% of women were excluded from the 400-m walk, while another 8% of men and 14% of women were unable to complete the 400-m walk. The percent of men and women excluded from or unable to complete the 400-m walk increased with increasing weight status at all three time points.

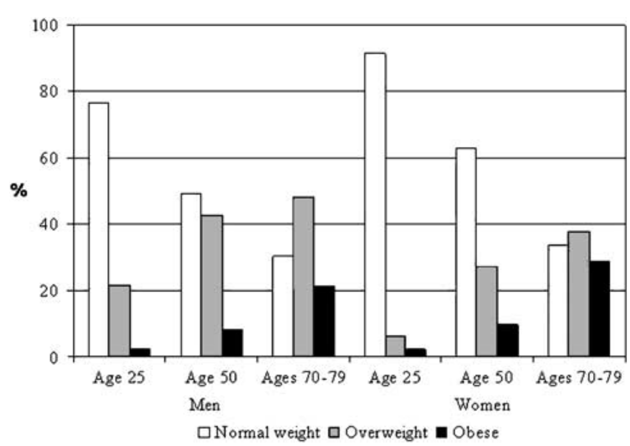

Figure 1 Prevalence of normal weight, overweight and obesity at ages 25, 50, and study baseline (ages 70–79): the Health ABC study. Health ABC study, Health, Aging and Body Composition study.

The adjusted mean physical performance measures by history of overweight or obesity at all three time points are shown in Table 3. In general, men and women who were normal weight at all three time points had significantly better SPPB scores and 400-m walk times than those who had a history of overweight or obesity ($P<0.05$). In addition, women who were overweight or obese at age 50 or earlier had significantly worse SPPB scores and 400-m walk times than those who were overweight or obese at study baseline (ages 70–79) but not at age 50 or 25. SPPB scores in men and women and 400-m walk times in women were also significantly worse in those who were normal weight at study baseline (ages 70–79) but had a history of overweight or obesity at age 50 compared to those who were normal weight at all three time points. Adjusting for prevalent health conditions at baseline attenuated the associations between a history of overweight or obesity and physical performance slightly, but in general, the associations remained significant. Similar associations between physical performance and a history of obesity were also observed (Table 4); however, substantially fewer participants ($\leqslant$10%) had a history of obesity in midlife or earlier.

Discussion

Obesity in young, middle and late adulthood was associated with worse physical performance in late adulthood compared to normal weight in both men and women. Overweight at the three time points was also generally associated with worse physical performance in late adulthood in women. Furthermore, having a history of overweight and/or obesity in midlife or earlier was associated with worse physical performance in both men and women compared to those who were normal weight and overweight and/or obese in late adulthood but who did not have a history of

Table 2 Physical performance measures (adjusted least-squares means (s.e.)) among men and women by weight status at ages 25, 50 and study baseline (ages 70–79): the Health ABC study

Weight history pattern	N	*HABC SPPB (score, 0–4)*		*Completed 400-m walk, n (%)*	*400-m walk time (s)*[a]	
		Model 1[b]	*Model 2*[c]		*Model 1*[b]	*Model 2*[c]
Men						
Age 25						
Normal weight	1058	2.30 (0.02)	2.30 (0.02)	859 (81.2)	321.5 (2.1)	321.6 (2.1)
Overweight	299	2.21 (0.03)*	2.22 (0.03)*	232 (77.6)	325.8 (3.4)	324.0 (3.4)
Obese	30	1.99 (0.09)*,†	1.99 (0.09)*,†	21 (70.0)	347.6 (10.7)*	345.8 (10.5)*,†
Age 50						
Normal weight	682	2.30 (0.02)	2.31 (0.02)	565 (82.8)	318.4 (2.4)	318.5 (2.4)
Overweight	590	2.27 (0.02)	2.28 (0.02)	471 (79.8)	325.2 (2.6)*	324.6 (2.6)*
Obese	115	2.06 (0.05)*,†	2.12 (0.04)*,†	76 (66.1)	342.5 (5.7)*,†	338.3 (5.7)*,†
Ages 70–79						
Normal weight	424	2.31 (0.02)	2.32 (0.02)	354 (83.5)	319.7 (2.8)	319.5 (2.8)
Overweight	667	2.28 (0.02)	2.30 (0.02)	535 (80.2)	318.9 (2.5)	318.7 (2.5)
Obese	296	2.15 (0.03)*,†	2.17 (0.03)*,†	223 (75.3)	340.7 (3.6)*,†	338.9 (3.6)*,†
Women						
Age 25						
Normal weight	1297	2.01 (0.02)	2.02 (0.02)	954 (73.6)	353.8 (2.5)	352.5 (2.4)
Overweight	88	1.87 (0.05)*	1.88 (0.05)*	55 (62.5)	368.0 (7.7)	369.6 (7.3)*
Obese	31	1.86 (0.09)	1.93 (0.08)	17 (54.8)	383.1 (13.6)*	372.2 (13.1)
Age 50						
Normal weight	891	2.07 (0.02)	2.07 (0.02)	679 (76.2)	346.1 (2.8)	346.0 (2.7)
Overweight	385	1.94 (0.03)*	1.95 (0.03)*	263 (68.3)	363.7 (3.7)*	361.3 (3.6)*
Obese	140	1.68 (0.04)*,†	1.74 (0.04)*,†	84 (60.0)	396.7 (6.4)*,†	389.4 (6.2)*,†
Ages 70–79						
Normal weight	477	2.11 (0.02)	2.10 (0.02)	368 (77.1)	344.1 (3.3)	344.9 (3.2)
Overweight	533	2.02 (0.02)*	2.03 (0.02)*	399 (74.8)	349.6 (3.2)	348.3 (3.1)
Obese	406	1.80 (0.03)*,†	1.82 (0.03)*,†	259 (63.8)	381.6 (3.9)*,†	377.0 (3.8)*,†

Abbreviations: Health ABC study, Health, Aging and Body Composition study; SPPB, short physical performance battery. [a]Results shown are for participants who completed the 400-m walk only. [b]Model 1 adjusted for age, race, field center, education, smoking status and physical activity. [c]Model 2 adjusted for variables in model 1 plus diabetes, CHD, CHF, stroke, COPD, knee pain, depression and cognitive impairment.*Significantly different from normal weight ($P<0.05$). †Significantly different from overweight ($P<0.05$).

overweight and/or obesity in midlife or earlier. This extends prior work based on self-report in other studies, which found obesity was associated with self-reported physical disability[6,9,10,13,15] and worse physical performance.[16–19] Previous studies showing that obesity among young and middle-aged adults predict physical disability in late-life relied on self-reported measures of physical function,[13–15] while this study used objectively measured physical performance. Physical performance tests are useful for predicting future disability, nursing home admission and mortality among high functioning elders.[20,21,24–26]

Obesity may lead to joint wear and tear, reduced exercise capacity and a higher rate of chronic disease such as cardiovascular disease, diabetes and arthritis, thus resulting in physical disability. The onset of obesity in young and middle adulthood may result in lower physical activity contributing to decreased muscle strength and cardiovascular fitness and greater declines in physical performance because of longer duration of excess body weight and earlier onset of chronic disease. Peeters *et al*.[27] found that obesity at ages 30–49 was associated with 5–6 fewer years free of limitations in ADLs after age 50 compared to those who were normal weight. In the ARIC study, participants who were obese at age 25 had approximately a twofold or higher prevalence of limitations in self-reported physical function and ADLs at ages 52–75.[15] Health ABC participants who had a history of being overweight or obese in midlife or earlier had worse physical performance than those who were normal weight throughout or who became overweight or obese in late adulthood.

It is, however, difficult to untangle the independent effects of reported weight status in young and middle adulthood vs weight status in late adulthood as they are often correlated. In the Health ABC cohort, weight status at age 25 and 50 and weight status at study baseline (ages 70–79) were moderately correlated ($r=0.31$ and $r=0.62$, respectively). This raises the issue of whether weight in the distant past or weight at study baseline was the driving force behind the associations seen between weight status at age 25 and 50 and physical performance in late adulthood and caution must be

Table 3 Physical performance measures (adjusted least-squares means (s.e.)) among men and women by history of overweight or obesity (BMI $\geqslant$25 kg/m^2) at ages 25, 50 and study baseline (ages 70–79): the Health ABC study

Weight history pattern	N	*Median BMI at ages 70–79*	*HABC SPPB (score, 0–4)*		*Completed 400 m walk, n (%)*	*400-m walk time (s)*[a]	
			Model 1[b]	*Model 2*[c]		*Model 1*[b]	*Model 2*[c]
Men							
Normal weight at all time points	427	23.7	2.34 (0.02)	2.34 (0.02)	359 (84.1)	315.7 (2.9)	315.9 (2.9)
Overweight or obese at ages 70–79	228	27.8	2.24 (0.03)*	2.24 (0.03)*	185 (81.1)	324.0 (3.9)	324.3 (3.8)
Overweight or obese at ages 70–79 and 50	317	29.3	2.28 (0.03)	2.30 (0.03)	251 (79.2)	327.9 (3.4)*	327.2 (3.4)*
Overweight or obese at ages 70–79, 50 and 25	251	29.8	2.18 (0.03)*,‡	2.19 (0.03)*,‡	189 (75.3)	329.1 (3.8)*	327.2 (3.8)*
Overweight or obese at age 50 but not at ages 70–79	137	24.7	2.22 (0.04)*	2.24 (0.04)*	107 (78.1)	325.4 (4.8)	324.3 (4.7)
Other	27	24.1	2.23 (0.09)	2.24 (0.09)	21 (77.8)	320.4 (10.7)	319.0 (10.5)
Women							
Normal weight at all time points	532	23.2	2.13 (0.02)	2.12 (0.02)	410 (77.1)	342.0 (3.3)	342.8 (3.2)
Overweight or obese at ages 70–79	344	28.3	1.98 (0.03)*	1.99 (0.03)*	259 (75.3)	353.9 (3.9)*	351.7 (3.8)*
Overweight or obese at ages 79–79 and 50	383	31.0	1.87 (0.03)*,†	1.90 (0.03)*,†	261 (68.2)	370.9 (3.8)*,†	366.6 (3.8)*,†
Overweight or obese at ages 70–79, 50 and 25	93	34.8	1.85 (0.05)*,†	1.88 (0.05)*	54 (58.1)	378.7 (7.6)*,†	375.5 (7.4)*,†
Overweight or obese at age 50 but not at ages 70–79	49	24.2	1.88 (0.07)*	1.90 (0.07)*	32 (65.3)	364.9 (9.7)*	364.1 (9.4)*
Other	15	25.0	1.89 (0.12)	1.86 (0.12)*	10 (66.7)	330.1 (17.3)‡,§	336.7 (16.7)§

Abbreviations: BMI, body mass index; Health ABC study, Health, Aging and Body Composition study; SPPB, short physical performance battery. [a]Results shown are for participants who completed the 400-m walk only. [b]Model 1 adjusted for age, race, field center, education, smoking status and physical activity. [c]Model 2 adjusted for variables in model 1 plus diabetes, CHD, CHF, stroke, COPD, knee pain, depression and cognitive impairment.*Significantly different from normal weight at all time points ($P<0.05$). †Significantly different from overweight or obese at ages 70–79 ($P<0.05$). ‡Significantly different from overweight or obese at ages 70–79 and 50 ($P<0.05$). §Significantly different from overweight or obese at ages 70–79, 50 and 25 ($P<0.05$).

Table 4 Physical performance measures (adjusted least-squares means (s.e.)) among men and women by history of obesity (BMI $\geqslant$30 kg/m^2) at ages 25, 50 and study baseline (ages 70–79): the Health ABC study

Weight history pattern	N	*Median BMI at ages 70–79*	*HABC SPPB (score, 0–4)*		*Completed 400 m walk, n (%)*	*400-m walk time (s)*[a]	
			Model 1[b]	*Model 2*[c]		*Model 1*[b]	*Model 2*[c]
Men							
Non-obese at all time points	1107	26.0	2.30 (0.02)	2.30 (0.02)	912 (82.4)	319.0 (2.1)	319.0 (2.0)
Obese at ages 70–79	146	32.8	2.21 (0.04)*	2.22 (0.04)*	108 (74.0)	342.0 (4.9)*	340.9 (4.8)*
Obese at ages 70–79 and 50	56	33.8	2.08 (0.06)*	2.11 (0.06)*	40 (71.4)	347.5 (7.8)*	344.7 (7.7)*
Obese at ages 70–79, 50 and 25	11	34.0	1.76 (0.14)*,†,‡	1.80 (0.14)*,†,‡	6 (54.6)	357.7 (19.7)*	352.1 (19.5)
Obese at age 50 but not at ages 70–79	48	27.6	2.12 (0.07)*,§	2.20 (0.07)§	30 (62.5)	333.5 (8.8)*	327.7 (8.8)
Other	19	24.2	2.14 (0.11)§	2.15 (0.11)§	16 (84.2)	331.8 (12.0)	331.2 (11.9)
Women							
Non-obese at all time points	1011	25.4	2.07 (0.02)	2.07 (0.02)	770 (76.2)	346.6 (2.6)	346.2 (2.5)
Obese at ages 70–79	238	33.5	1.85 (0.03)*	1.87 (0.03)*	153 (64.3)	375.1 (4.7)*	372.2 (4.6)*
Obese at ages 70–79 and 50	88	36.5	1.63 (0.05)*,†	1.67 (0.05)*,†	53 (60.2)	398.8 (7.8)*,†	391.5 (7.6)*,†
Obese at ages 70–79, 50 and 25	18	37.9	1.89 (0.11)‡	1.95 (0.11)‡	9 (50.0)	369.5 (18.0)	359.2 (17.4)
Obese at age 50 but not at ages 70–79	34	29.3	1.69 (0.08)*	1.76 (0.08)*	22 (64.7)	404.7 (11.6)*,†	399.7 (11.2)*,†,§
Other	27	19.4	2.09 (0.09)†,‡	2.10 (0.09)†,‡	19 (70.4)	353.7 (12.5)‡	351.6 (12.0)‡

Abbreviations: BMI, body mass index; Health ABC study, Health, Aging and Body Composition study; SPPB, short physical performance battery. [a]Results shown are for participants who completed the 400-m walk only. [b]Model 1 adjusted for age, race, field center, education, smoking status and physical activity. [c]Model 2 adjusted for variables in model 1 plus diabetes, CHD, CHF, stroke, COPD, knee pain, depression and cognitive impairment.*Significantly different from non-obese at all time points ($P<0.05$). †Significantly different from obese at ages 70–79 ($P<0.05$). ‡Significantly different from obese at ages 70–79 and 50 ($P<0.05$). §Significantly different from obese at ages 70–79, 50 and 25 ($P<0.05$).

exercised in the interpretation of results. Participants who reported being overweight or obese in midlife or earlier were heavier in late adulthood than those who became overweight or obese later in life.

Sarcopenia, the age-associated loss of muscle mass, may also occur in the presence of obesity and thus contribute to worse physical performance among older adults. Baumgartner *et al.*[28,29] have shown that older adults with sarcopenic obesity were more likely to report instrumental ADL disability and abnormalities in gait and balance compared to those with who were sarcopenic or obese alone. However, others have not found an association between sarcopenic obesity and functional limitations.[30,31] In the Health ABC cohort, Visser *et al*.[32] previously examined the cross-sectional association between muscle mass, muscle composition and total body fat with physical performance and found that muscle mass and muscle attenuation were positively associated with physical performance while total body fat was inversely associated with physical performance. Muscle mass was most strongly associated with physical performance in men, whereas total body fat was most strongly associated with physical performance in women.

Although the differences in physical performance measures between weight status groups were modest, they are at levels demonstrated to be clinically meaningful.[33,34] Perera *et al*.[33] demonstrated that a change of 0.5 points on the original SPPB (range of 0–12[20]) represents a small meaningful change, while a change of 1.0 points represents a substantial meaningful change. This would be equivalent to approximately a difference of 0.16 and 0.33 points, respectively, on the Health ABC SPPB. In the Health ABC cohort, Newman *et al*.[34] showed that for the 400-m walk, each additional minute in walk time (1 s.d.) was associated with 52% higher rates of mobility limitation and disability and a 29% higher rate of mortality.

A limitation of the work presented here is the use of recalled weight and height from the distant past. In the Charleston Heart Study, recalled weight was highly correlated ($r=0.82$) with weight measured 28 years earlier among white and black men and women aged 62–100.[35] Others have also shown high correlations ($r\geqslant 0.80$) between recalled and measured weight in young adulthood among middle-aged and older men and women.[36,37] In the Health ABC cohort, self-reported and measured weight at study baseline (ages 70–79) was highly correlated ($r=0.98$). The correlation between recalled height at age 25 and measured height at study baseline was also high ($r=0.93$; mean difference of $+3$ cm). Other studies have also shown high correlations between self-reported and measured height among older adults ($r\geqslant 0.77$), with a mean difference of approximately 2–3 cm.[38,39] However, the over-reporting of height among older adults may be due, in part, to the loss of height associated with aging,[40] and may actually more accurately reflect height in younger adulthood. In analyses that used measured height at study baseline in place of recalled height at age 25 to calculate BMI and in analyses that excluded participants who were classified as cognitively impaired ($n=186$), results were similar.

There are important characteristics of the Health ABC cohort which limit the generalization of these findings. First, participants were recruited to be well functioning and free of lower-extremity functional limitations at baseline. It is possible that the associations between weight status and physical performance may have been stronger had participants of all stages of functional ability been included. Second, a substantial number of participants were excluded from ($n=345$) or were unable to complete ($n=320$) the 400-m walk, possibly resulting in selection bias. However, the proportion of those who were excluded or were unable to complete the 400-m walk was progressively higher among those who were overweight and obese compared to normal weight at each age studied. Finally, the observational nature of our study does not allow us to evaluate a causal association between weight status and weight history and physical performance. It is biologically plausible that a history of excess weight may result in poor physical performance. However, although the analyses were adjusted for smoking, physical activity and prevalent health conditions at study baseline, weight status and weight history may serve as a proxy measure for other relevant participant characteristics that may lead to both overweight and obesity and poor physical performance. It is possible, for example, that excess weight was the result of a history of physical inactivity, which ultimately resulted in poor physical performance.

In conclusion, excess weight in young, middle and late adulthood was associated with worse physical performance in this well-functioning cohort of older adults. Those with a history of excess weight in midlife or earlier also tended to have worse physical performance compared to those who were normal weight throughout or who were overweight and/or obese in late adulthood but not in midlife or earlier. These data suggest that interventions targeting the prevention of overweight and obesity in young and middle-aged adults may be useful in preventing or delaying the onset of physical disability later in life. Given the demonstrated association between overweight and obesity from young to late adulthood and physical performance in late adulthood, the dramatic increase in overweight and obesity in the US may lead to an increase in the prevalence of physical disability among future generations of older adults.

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