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Research Article

The Influence of Physical Activity and Sedentary Behavior on Living to Age 85 Years Without Disease and Disability in Older Women

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Abstract

Background: Whether physical activity (PA) and sedentary behavior influence the odds of women living to age 85 years without chronic disease or disability is not well described.

Methods: Participants of the Women's Health Initiative (n = 49,612) were categorized based on health status by age 85 years: (i) lived without developing major chronic disease or mobility disability ("healthy"); (ii) lived and developed mobility disability with or without disease; (iii) lived and developed major chronic disease, but not mobility disability; and (iv) died before their 85th birth year. Multinomial logistic regression models that adjusted for covariates such as age, race/ethnicity, and body size estimated associations of self-reported PA and sitting time on developing major disease or mobility disability or dying before age 85 relative to being healthy.

Results: Mean ± *SD* baseline age was 70.2 ± 3.6 years. Distributions were: 22% healthy, 23% had mobility disability, 26% had major disease, and 29% died. Relative to those with high total PA, the adjusted odds ratios (OR) (confidence intervals [CI]) for mobility disability was 1.6 (1.4–1.7), 1.2 (1.1–1.3), and 1.1 (1.0–1.2) for women with no, low, and moderate total PA, respectively (p-trend < .001). The corresponding covariate-adjusted OR (CI) for mortality was 1.7 (1.5–1.8), 1.2 (1.1–1.3), and 1.0 (1.0–1.1) (p-trend < .001). Total PA was not associated with developing chronic disease before age 85 years. Sitting ≥10 relative to <5 hours per day increased the odds of mobility disability (1.1, CI: 1.0–1.3) and mortality (1.2, CI: 1.0–1.3) prior to age 85 years (p < .001).

Conclusions: Increasing PA to recommended levels and reducing sitting time are modifiable behaviors that may improve healthy aging in older women.

Keywords: Late-age survival, Exercise, Sitting time, Mobility disability, Mortality

For adults who reach age 85 years in 2050, the average life expectancy for men and women is 7.0 and 8.5 years, respectively (1). Adults desire living to that age free of major morbidity and disability and countries with growing populations of older adults want lower rates of disability and chronic disease to minimize health care and nursing home burden and costs (2). Identifying modifiable predictors of maintaining health in older ages would have substantial public health impact and importance.

Studies have consistently reported a strong and positive association between physical activity (PA) and healthy aging (3,4), broadly defined as living to a later age without major disease and/or physical or cognitive dysfunction. For older adults, even engagement in modest levels of PA has been shown to meaningfully reduce mortality (5–8), morbidity (6,9), and disability risks (10–12). Given these relationships, one could postulate that higher amounts of PA would increase the likelihood for healthy aging. Excessive time spent sedentary has also emerged as a risk factor for mortality, chronic disease, and disability that is independent of PA (13–15). However, few studies have examined these relationships among women aged 85 years and older within the context of healthy aging.

Using prospective data from the Women's Health Initiative (WHI), we examined the association of PA level and sitting time, collected at age 62–81 years, on survival to age 85 years with and without mobility disability and major chronic disease. We previously reported that higher body mass index (BMI) was associated with a lower likelihood of healthy survival to age 85 years (16) and recognize that PA and sedentary behavior patterns differ by body size (17) and race/ethnicity (17–19). We follow-up on our earlier report in order to robustly investigate the relationship between PA and sedentary behavior with late-age survival, including subgroup evaluations for race/ethnicity and BMI.

Methods

Enrollment in the main WHI study has been detailed in ref. (20). From 1993 to 1998, the WHI study enrolled a sample of postmenopausal women aged 50–79 years from 40 U.S. clinical centers. Enrollees participated in one to three clinical trials or an observational study. The main WHI study concluded in 2005 and extension studies continue collection of primary outcomes, including cancers, cardiovascular disease, and deaths. Written informed consent was obtained from all participating women at the main WHI and extension study enrollments. Institutional Review Boards at all participating institutions approved the protocols and procedures.

WHI women born prior to September 21, 1930 comprised the analytic sample for this study. This birth cutoff date identified women who could live to age 85 or older at the time that the outcomes were last adjudicated on September 20, 2015. Women were classified into four mutually-exclusive categories: (i) lived to age 85 without major chronic disease or mobility disability ("healthy"); (ii) lived to age 85 with mobility disability that developed during follow-up, regardless of disease status; (iii) lived to age 85 and diagnosed with disease, but not mobility disability, that developed during follow-up; or (iv) died before their 85th birth year. Women were characterized with major chronic disease if they developed cardiovascular disease, cerebrovascular disease, cancer (except nonmelanoma skin cancer), Type-2 diabetes, and/or hip fracture before turning age 85. These conditions were chosen because they account for a sizeable proportion of late-life morbidity in older women (21). Incident cancers were adjudicated by trained physicians. Before 2010, all hip fracture and cardiovascular and cerebrovascular disease events were physician-adjudicated, but starting in 2010, these conditions were also identified by self-reported physician diagnosis (22,23). Diabetes was defined by self-reported physician diagnosis that included treatment prescriptions (24). Women were considered to have a mobility disability if they reported that their health greatly affected their ability to walk one block or one flight of stairs on the RAND 36-Item Health Survey (25) or required an assistive tool (crutch, walker, or wheelchair, but not cane) for walking. Deaths were confirmed by adjudicated medical records, autopsy reports, and death certificates and the National Death Index was reviewed periodically for all WHI participants, including those lost to follow-up. To address reverse causation and misclassification bias, women with chronic disease or mobility disability at baseline (n = 8,744) and women without a follow-up visit within 18 months of their 85th birth year (n = 7,000) were excluded.

A clinic visit and standardized questionnaires were administered at baseline. PA was collected from questionnaires that asked about the weekly frequency and duration of walking outside the home for >10 minutes without stopping and other PA engagement at three intensity levels (vigorous, moderate, and light), which has been tested as reliable and valid (26). Responses were used to estimate energy expenditure, in metabolic equivalents hours per week (MET-hr/wk) (27). A significant proportion (14%) of women was found to have zero MET-hr/wk of PA, suggesting no PA participation. Therefore, four exposure categories were created: no PA, and low, moderate, or high PA based on tertiles of estimated energy expenditure among the women with over zero MET-hr/wk of activity. Sedentary behavior was based on a question about the number of hours per day spent sitting and had eight categorical responses listed ranging from less than 4 hours to 16 hours or more (28). These categories were further grouped into less than 5, 6–9, and 10 or more hours per day. The question about sedentary behavior was asked only among WHI women participating in the observational study (n = 29,090).

Baseline covariates included age, race/ethnicity, education, marital status, hormone therapy use, smoking and alcohol use, BMI, self-rated health, and depression. Race/ethnicity was self-identified as White, Black/African American, Hispanic/Latina, or Asian/Pacific-Islander. Clinic staff obtained height and weight measures, which was used to calculate BMI (kg/m^2). Self-rated health was a score from the RAND-36 quality of life subscale on general health (25) that ranged from one to 100, with higher values indicating a more favorable health state. Depression was identified based on a score of >0.06 (range: 0–1) in the shortened version of the Center for Epidemiologic Studies Depression scale (29).

Frequencies or means and standard deviations (SD) for categorical or continuous variables were reported across the four outcome groups. Since four mutually exclusive outcomes are possible, multinomial logistic regression models were used to estimate the association of PA or sedentary behavior with the outcomes, using "healthy" women as the referent. Specifically, odds ratios (OR) and 95% confidence intervals (CI) were used to approximate risk measures by comparing the probability of developing chronic disease, mobility disability, or death before the woman's 85th birth year relative to being healthy across the PA or sedentary behavior exposures. The models adjusted for race/ethnicity, WHI study participation type, and baseline age, education (less than high school, high school graduate, some college, and college graduate), marital status (married, divorced, widowed, and never married), hormone therapy use (yes/no), smoking status (non, past, and current), alcohol use (never, past drinker, drinks <1/wk, and drinks ≥1/wk), BMI, self-rated health, and depression (yes/no). Age (mean-centered), BMI, and self-rated health were included in the models as continuous variables; all other covariates were categorical. To examine associations of sedentary behavior independent of PA, models using sitting time as the exposure also included a continuous value of MET-hr/wk from total PA. Since late-age survival outcomes and PA patterns vary by BMI (16,17) and racial/ethnic groups (17–19), separate regression models included product terms for BMI category (underweight excluded, n = 498) and race/ethnicity by PA or sedentary behavior to test for interactions on the multiplicative scale. Analyses were executed using SAS v9.3 (SAS Institute Inc., Cary NC).

Results

Mean (*SD*) baseline age was 70.2 (3.6) years (range: 62–81) and participants were followed for an average (*SD*) of 13.7 [5.1] years. Outcome distributions were: 22% healthy, 23% developed mobility disability, 26% developed chronic disease but no mobility disability, and 29% died before age 85 years. Distributions differed by baseline characteristics for women who were healthy compared to women in all of the other outcome groups (Table 1). For example, the lowest BMI levels and highest self-rated scores were observed among women in the healthy group. In addition, Black/African American and Hispanic/Latina women and women who were smokers or depressed were less likely to be in the healthy group. Among those with no total PA, 28% developed a mobility disability, 21% developed chronic disease, and 37% died, while 14% were healthy. For women who sat ≥10 hours daily, 23% developed a mobility disability, 24% developed chronic disease and 35% died, while 18% were healthy (Table 1).

A dose–response association between total PA and odds of mobility disability or death before age 85 years was observed (Table 2). Compared to those with high total PA, the adjusted OR (CI) of developing a mobility disability were 1.57 (1.41–1.74), 1.22 (1.13–1.33), and 1.11 (1.03–1.20) for women with no, low, and moderate PA, respectively (p-trend < .001). For mortality, the adjusted OR (CI) was 1.66 (1.50–1.84), 1.23 (1.14–1.33), and 1.04 (0.96–1.12) for those with no, low, and moderate PA, respectively, compared to women with high PA (p-trend < .001). No associations were observed between total PA and developing chronic disease. Relationships were similar when the exposure was walking activities only (Table 2). Sitting for ≥10 versus ≤5 hours daily resulted in higher odds of developing mobility disability (1.14, CI: 1.02–1.29) and death (1.16, CI: 1.04–1.29), but not developing chronic disease (1.00, CI: 0.90–1.11), even after adjustment of covariates including total PA.

The elevated risks of developing a mobility disability among women with no PA were observed among Whites, Latina/Hispanics, and Asian/Pacific Islanders, but not Blacks/African Americans (Table 3). Relative to those with high PA, the adjusted OR (CI) of developing mobility disability for women with no PA were 1.57 (1.41–1.75), 2.68 (1.15–6.24), and 2.87 (1.33–6.20) for Whites, Latina/Hispanics, and Asian/Pacific Islanders, respectively, but was

Table 1. Baseline Characteristics by Outcomes

	Lived to Age 85 y With:			
	No Chronic Disease and No Mobility Disability, *N* (%) or Mean ± *SD*	Mobility Disability With or Without Disease, *N* (%) or Mean ± *SD*	Chronic Disease but no Mobility Disability, *N* (%) or Mean ± *SD*	Died Before Age 85, *N* (%) or Mean ± *SD*
Overall	10,716 (21.6)	11,414 (23.0)	12,949 (26.1)	14,533 (29.3)
WHI Observation Study Only	6,011 (20.7)	6,126 (21.1)	7,804 (26.8)	9,149 (31.5)
Age, years	71.0 ± 3.7	69.7 ± 3.3	70.6 ± 3.8	69.8 ± 3.4
Race/ethnicity				
White	9,769 (22.3)	10,081 (23.1)	11,381 (26.0)	12,500 (28.6)
Black/African American	401 (13.1)	692 (22.6)	772 (25.2)	1,200 (39.2)
Hispanic/Latina	172 (17.7)	226 (23.3)	253 (26.1)	320 (33.0)
Asian/Pacific Islander	220 (22.0)	218 (21.8)	313 (31.2)	251 (25.1)
College Graduate	4,524 (25.1)	3,879 (21.5)	4,851 (26.9)	4,795 (26.6)
Married/Living as married	6,292 (22.9)	6,413 (23.4)	7,401 (27.0)	7,344 (26.8)
Uses Hormone Therapy	4,714 (22.6)	4,985 (23.9)	5,363 (25.7)	5,813 (27.9)
Current Smoker	266 (10.1)	490 (18.7)	470 (17.9)	1,401 (53.3)
Alcohol Intake				
Nondrinker	1,064 (18.3)	1,479 (25.5)	1,498 (25.8)	1,763 (30.4)
Past Drinker	1,421 (14.9)	2,375 (24.9)	2,225 (23.3)	3,537 (37.0)
<1 drink/week	3,345 (21.5)	3,762 (24.2)	4,177 (26.8)	4,276 (27.5)
≥1 drink/week	4,823 (26.4)	3,698 (20.2)	4,955 (27.1)	4,825 (26.4)
General Health SF-36 Score	80.1 ± 13.9	70.9 ± 17.0	75.4 ± 15.7	68.5 ± 19.1
Depression	526 (13.0)	1,123 (27.7)	872 (21.5)	1,533 (37.8)
Body mass index, kg/m^2	26.0 ± 4.4	29.1 ± 5.7	27.1 ± 4.9	28.1 ± 6.1
Total physical activity (MET-hours/week)				
None (0)	933 (13.7)	1896 (27.9)	1432 (21.1)	2536 (37.3)
Low (0.5 to <7)	2563 (18.6)	3431 (24.9)	3369 (24.5)	4406 (32.0)
Moderate (≥7 to <16.5)	2950 (23.0)	2872 (22.4)	3548 (27.6)	3482 (27.1)
High (≥16.5)	3657 (26.7)	2662 (19.4)	3972 (29.0)	3407 (24.9)
Hours/day Sitting[a]				
10 or more	959 (17.9)	1210 (22.5)	1314 (24.4)	1893 (35.2)
6–9	2712 (20.9)	2813 (21.7)	3460 (26.7)	3985 (30.7)
5 or less	2296 (21.9)	2063 (19.7)	2953 (28.2)	3168 (30.2)

Note: Row percentages shown. MET = Metabolic equivalents; WHI = Women's Health Initiative. General Health SF-36 score ranges from 1 to 100, with higher scores suggestive of a more favorable health state.

[a]Observational Study only.

Table 2. Associations of Physical Activity or Sedentary Behavior on Outcomes

		Lived to Age 85 With no Chronic Disease and no Mobility Disability Relative to:		
	%	Lived to Age 85 With Mobility Disability With or Without Disease OR[a] (95% CI)	Lived to Age 85 With Disease but no Mobility Disability OR[a] (95% CI)	Died Before Age 85 y OR[a] (95% CI)
Total physical activity (MET-hours/week)		*		*
None (0)	14.4	1.57 (1.41–1.74)	1.09 (0.99–1.21)	1.66 (1.50–1.84)
Low (0.5 to <7)	29.2	1.22 (1.13–1.33)	0.98 (0.91–1.05)	1.23 (1.14–1.33)
Moderate (≥7 to <16.5)	27.3	1.11 (1.03–1.20)	1.01 (0.94–1.08)	1.04 (0.96–1.12)
High (≥16.5)	29.1	Ref	Ref	Ref
Walking only (MET-hours/week)		*		*
None (0)	31.4	1.48 (1.36–1.60)	0.99 (0.92–1.07)	1.52 (1.41–1.65)
Low (0.5 to <3.5)	21.1	1.32 (1.21–1.44)	0.99 (0.91–1.08)	1.29 (1.18–1.40)
Moderate (≥3.5 to <7.5)	20.9	1.11 (1.10–1.21)	1.00 (0.92–1.08)	1.13 (1.04–1.22)
High (≥7.5)	26.6	Ref	Ref	Ref
Hours/day Sitting[b]		*		*
10 or more	18.7	1.14 (1.02–1.29)	1.00 (0.90–1.11)	1.16 (1.04–1.29)
6–9	45.0	1.09 (0.99–1.19)	0.98 (0.91–1.07)	1.02 (0.94–1.11)
5 or less	36.4	Ref	Ref	Ref

Note: CI = Confidence interval; MET = Metabolic equivalents; OR = Odds ratio.
[a]Adjusted for race/ethnicity, WHI study participation type, and baseline age, education, marital status, hormone therapy use, smoking status, alcohol use, body mass index, self-rated health, and depression. [b]Observational Study only and included adjustment of continuous MET-hours/wk from total physical activity.
*p-trend ≤ .05.

0.99 (0.62–1.58) for Blacks/African Americans (p-interaction < .05). The relationship of PA or sitting time on mortality did not differ by race/ethnicity (Table 3). A dose–response association of total PA and incident mobility disability or death was observed when stratified by BMI categories, although interaction tests were not statistically significant (Supplementary Table 1).

Discussion

This analysis of generally healthy and ambulatory older women with an average 13.5 years of follow-up showed that higher PA levels were associated with a lower risk of developing mobility disability or dying before age 85 years. An increased risk of mobility disability and death by age 85 was also observed for women with prolonged sitting time that was independent of PA.

The finding that higher levels of PA was associated with lower risk of mortality has been previously reported in studies that combined older men and women (5,7,8), although studies rarely examined older women separately (6). Most studies focused on moderate-to-vigorous PA (5,7,8) even though participation at that PA intensity among older women is low (30). We also considered energy expenditure from walking only and observed higher mortality risks associated with lower levels of walking, which is a moderate intensity activity when performed at self-pace in older adults (31). Walking per se is seldom examined separately from moderate-to-vigorous PA even though it is the most common leisure-time activity engaged in among U.S. adults, including older adults (32). While higher mortality risks were observed for women with lower levels of walking-related energy expenditure, the largest escalation in risk occurred between never walkers and those with the lowest levels of walking, highlighting the potential health benefit that might be obtained even by modest amounts of walking at later ages.

The relationship of PA, that includes walking, on developing disability has also been described in the literature, although disability definitions vary widely (10–12). A study of nearly 4,000 adults aged 65 years or older with 12 years of follow-up found up to a 2.1-fold risk of disability, defined using impaired mobility and activities of daily living, among those who walked less than 1 hour daily and/or exercised once a week or less (10). A clinical trial of adults 70–89 years old with mild physical limitations showed that participants randomized to a moderate-to-vigorous intensity PA program experienced an 18% lower hazard of developing major mobility disability after 2.6 years of follow-up compared to subjects randomized to a health education program only (11). Women aged 65 years and older who walked at least eight blocks every week at baseline had a greater likelihood of maintaining their walking ability and speed 1 year later relative to women who walked less than eight blocks per week at baseline (12). Our results for mobility disability were similar to mortality—an incremental higher risk for those with low and moderate MET-hr/wk of PA, but even greater risk among women with no PA, including walking.

Our analysis showed PA was not associated with risk of developing major chronic disease before age 85, in contrast to other studies of adults aged 65 years and older (6,9). However, other studies tended to focus on a single, specific chronic condition, such as diabetes (9) or cardiovascular disease (6). Our definition of major chronic disease was based on the development of at least one of five conditions that are highly prevalent in older women, including diabetes, cardiovascular disease, and cancer. Furthermore, women in our study were only classified as developing disease if they did not die or develop mobility disability during follow-up. In other words, women in our study with mobility disability or who died might have also developed disease and, for these women, mobility limitations or earlier death could have been caused by symptoms or side effects of their chronic disease (eg, impaired gait from a stroke). The lack of associations observed between PA and risk of major chronic disease might be because women in the diseased group may be healthier. The decision to prioritize mobility disability acknowledges the notion that maintaining ambulation is closely tied to functional independence, quality of life, perceived health, and death (33).

Table 3. Associations of Physical Activity or Sedentary Behavior on Outcomes by Race/Ethnicity

		Lived to Age 85 With no Disease and no Mobility Disability Relative to:		
	%	Lived to Age 85 With Mobility Disability With or Without Disease OR[a] (95% CI)	Lived to Age 85 With Disease But no Mobility Disability OR[a] (95% CI)	Died Before Age 85 y OR[a] (95% CI)
White				
Total physical activity (MET-hours/week)		*		*
None (0)	13.9	1.57 (1.41–1.75)	1.08 (0.97–1.21)	1.65 (1.48–1.83)
Low (0.5 to <7)	28.6	1.25 (1.15–1.36)	0.99 (0.92–1.07)	1.23 (1.14–1.34)
Moderate (≥7 to <16.5)	27.6	1.13 (1.04–1.22)	1.01 (0.94–1.09)	1.04 (0.96–1.13)
High (≥16.5)	29.8	Ref	Ref	Ref
Hours/day Sitting[b]		*		*
10 or more	18.9	1.16 (1.02–1.30)	1.01 (0.90–1.13)	1.18 (1.05–1.32)
6–9	45.7	1.08 (0.99–1.19)	0.99 (0.91–1.08)	1.04 (0.95–1.13)
5 or less	35.4	Ref	Ref	Ref
Black/African American				
Total physical activity (MET-hours/week)				
None (0)	21.2	0.99 (0.62–1.58)**	0.88 (0.56–1.38)	1.36 (0.87–2.12)
Low (0.5 to <7)	35.2	0.75 (0.50–1.11)**	0.66 (0.46–0.97)	1.04 (0.71–1.51)
Moderate (≥7 to <16.5)	23.3	0.81 (0.53–1.23)	0.84 (0.57–1.25)	1.07 (0.72–1.60)
High (≥16.5)	20.3	Ref	Ref	Ref
Hours/day Sitting[b]				
10 or more	17.3	1.28 (0.68–2.41)	0.80 (0.45–1.43)	0.91 (0.52–1.59)
6–9	37.6	1.24 (0.77–2.00)	0.79 (0.51–1.21)	0.81 (0.53–1.23)
5 or less	45.1	Ref	Ref	Ref
Latina/Hispanic				
Total physical activity (MET-hours/week)		*		*
None (0)	16.6	2.68 (1.15–6.24)	2.02 (0.89–4.60)	3.22 (1.43–7.25)
Low (0.5 to <7)	32.0	1.23 (0.65–2.32)	1.23 (0.68–2.22)	1.46 (0.80–2.67)
Moderate (≥7 to <16.5)	27.4	1.20 (0.63–2.28)	1.22 (0.67–2.20)	1.08 (0.58–2.00)
High (≥16.5)	23.9	Ref	Ref	Ref
Hours/day Sitting[b]				
10 or more	12.3	0.56 (0.19–1.62)	0.54 (0.20–1.47)	0.58 (0.22–1.52)
6–9	37.8	0.63 (0.30–1.31)	0.91 (0.47–1.75)	0.70 (0.36–1.36)
5 or less	49.9	Ref	Ref	Ref
Asian/Pacific Islander				
Total physical activity (MET-hours/wk)		*		
None (0)	12.2	2.87 (1.33–6.20)	1.67 (0.81–3.45)	2.05 (0.96–4.38)
Low (0.5 to <7)	31.0	1.01 (0.58–1.76)	0.90 (0.56–1.46)	1.05 (0.63–1.77)
Moderate (≥7 to <16.5)	26.2	0.72 (0.40–1.28)	0.83 (0.51–1.35)	0.67 (0.39–1.16)
High (≥16.5)	30.6	Ref	Ref	Ref
Hours/day Sitting[b]				
10 or more	21.0	0.85 (0.38–1.90)	1.07 (0.55–2.06)	1.29 (0.65–2.55)
6–9	42.5	1.53 (0.82–2.85)	1.07 (0.62–1.83)	1.06 (0.60–1.88)
5 or less	36.6	Ref	Ref	Ref

Note: CI = Confidence interval; MET = Metabolic equivalents; OR = Odds ratio.

[a]Adjusted for WHI study participation type, and baseline age, hormone therapy use, education, marital status, body mass index, smoking status, alcohol use, self-rated health, and depression. [b]Observational Study only and included adjustment of continuous MET-hours/week from total physical activity.

*p-trend ≤ .05. **p-interaction ≤ .05 relative to White.

We observed an increased risk of death and mobility disability, but not chronic disease, associated with large amounts of time spent sitting per day, even after adjustment for total PA. Excessive time spent sedentary and higher risk of mortality and disability is consistent with the literature (14,15). In a study of older women aged 76 years and older followed for up to 9 years, Pavey and colleagues reported a 1.45 and 1.65 higher risk of death among those who sat 8–11 and >11 hours per day, respectively, compared to those who sat <4 hours per day (15). Similarly, a study of over 134,000 older adults whose mean baseline age was 61 years with 8 years of follow-up showed a higher risk of mobility disability associated with more time spent sedentary that was exacerbated in those with the lowest PA levels (14). However, we found no association between sedentary behavior and development of chronic disease. Again, women in our study with chronic disease likely represented a healthier sample compared to women with mobility disability. Furthermore, sedentary behavior is related to late-age physical function (34,35) and thus, associations may be more apparent for mobility disability than for chronic disease.

The relationship between no PA and higher risk for mobility disability and mortality at age 85 was observed in all race/ethnicities except for Black/African American women. It is unclear why. Black/African American women might be more prone to measurement error. Black/African American women in our study were more likely to report no participation in any PA, yet no risk associations were seen. Lower prevalence of self-reported PA among non-Hispanic black populations has been reported in large, national surveillance studies (18). If Black/African American women in WHI underreport their actual PA, associations would be biased towards null. Another possible explanation is that the Black/African American women who lived to age 85 might be healthier than their counterparts from other races/ethnicities and less susceptible to the effects of PA on developing disability. The largest proportion of deaths occurred among Black/African Americans. If these women represented a less healthy subset, the PA effects would be minimized. More research is needed. However, the relationship of prolonged sitting time on the outcomes did not differ by race/ethnicity. Furthermore, PA and sedentary behavior associations on the late-age survival outcomes did not differ by baseline BMI, suggesting that normal weight, overweight, and obese women could possibly increase the likelihood for healthy aging to age 85 through more PA and less time spent sitting.

There are study limitations. We did not examine PA changes over time, such as whether women active at baseline maintained or stopped their activity. A study of older adults who reported moderate-to-vigorous PA at baseline showed participants retained a strong likelihood of healthy aging if they became inactive 4 years later, but those who remained active had even greater increases in their odds of healthy aging (3). Accelerometer-measured PA and sedentary behavior is becoming more prevalent in prospective cohort studies on aging. However, retrospective analysis of studies with many years of follow-up that rely on self-reported measures of PA and sedentary behavior still provide valuable information serving as a backdrop against which results that use objective measures can be interpreted. Finally, our PA questions were limited to walking and aerobic exercise and do not include resistance training or nonleisure activities, despite evidence that non-leisure activity represents a sizeable proportion of overall activity in older adults (36). Thus, our exposure estimates may be underreported.

Study strengths include a diverse sample of older women, allowing investigation of race/ethnicity and BMI interactions. We had many years of study follow-up, providing ample time for chronic disease and mobility disability development and death. Most diseases were validated through physician adjudication, which minimized self-reporting bias. We reduced the likelihood of reverse causation by excluding women with baseline disease or mobility disability and excluded women without lost to follow-up close to their 85th birth year, improving the accuracy of our outcomes. We evaluated walking only, improving knowledge about the individual contribution of walking on healthy aging and the risks on disability, disease, and death. Finally, we examined a direct measure of sedentary behavior as daily hours spent sitting that is distinct from low to no PA.

Engagement in higher levels of PA was associated with lower risks of developing mobility disability and of dying before age 85 years in older women. The highest risks were among women who did not participate in any leisure-time PA. These findings emphasize the public health and clinical value of limiting time spent sedentary and encouraging any type of PA, with particular focus on walking as a viable and widely accessible activity, in order to improve the chances for aging well in older women.

Supplementary Material

Supplementary data is available at *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences* online.

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Conflicts of Interest

None reported.

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