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The Association of Walking Pace and Incident Heart Failure and Subtypes Among Postmenopausal Women

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Abstract

BACKGROUND: To investigate the association between walking pace and the risk of heart failure (HF) and HF sub-types.

METHODS: We examined associations of self-reported walking pace with risk of incident HF and HF subtypes of preserved (HFpEF) and reduced (HFrEF) ejection fractions, among 25,183 postmenopausal women, ages 50-79 years. At enrollment into the Women's Health Initiative cohort in 1993-1998, this subset of women was free of HF, cancer, or the inability to walk one block, with self-reported information on walking pace and walking duration. Multivariable Cox regression was used to examine associations of walking pace (casual <2 mph [referent], average 2-3 mph, and fast >3 mph) with incident HF. We also examined the joint association of walking pace and duration with incident HF.

RESULTS: There were 1455 incident adjudicated acute decompensated HF hospitalization cases during a median of 16.9 years of follow-up. There was a strong inverse association between walking pace and overall risk of HF (HR=0.73, 95%CI [0.65, 0.83] for average vs casual walking; HR=0.66, 95%CI [0.56, 0.78] for fast vs casual walking. There were similar associations of walking pace with HFpEF (HR=0.73, 95%CI [0.62, 0.86] average vs casual; HR=0.63, 95%CI [0.50, 0.80] for fast vs casual), and with HFrEF (HR=0.72, 95%CI [0.57, 0.91] for average vs casual; HR=0.74, 95%CI [0.54, 0.99] for fast vs casual). The risk of HF associated with fast walking with less than 1 hour/week walking duration was comparable with the risk of HF among casual and average walkers with more than 2 hours/week walking duration.

CONCLUSION: Walking pace was inversely associated with risks of overall HF, HFpEF, and HFrEF in postmenopausal women. Whether interventions to increase the walking pace in older adults will reduce HF risk, and whether fast pace will compensate for the short duration of walking warrants further study.

Keywords

heart failure; physical activity; walking pace; postmenopausal; women

INTRODUCTION

Heart failure (HF) is an increasingly prevalent public health problem, accounting for more than 800,000 hospitalizations in 2016 and 83,000 deaths in 2018 in the United States. Prevalence of HF in the U.S. is projected to increase by 46% from 2012 to 2030, affecting more than 8 million people. HF predominantly affects older adults; with an approximate prevalence of 4 and 11 percent among 60-80 and older than 80 years old women, respectively. We still lack data defining the optimal lifestyle interventions to prevent HF

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in this population especially HF with preserved ejection fraction (HFpEF) which has no effective therapy, and is more common in women, older adults, and those with multiple comorbidities. [1]

Physical activity (PA) has been associated with lower risk of HF[2], but the role of specific types of PA remains to be elucidated. Walking, which essentially does not require any equipment, is the most common type of PA, especially for women and older adults.[3] Walking volume (MET-hrs/week) has been shown to be inversely related to incident coronary heart disease, cardiovascular disease (CVD), CVD-specific and all-cause mortality in older women.[4] A few studies have evaluated walking pace independent of walking duration and found that those with a faster walking pace had a lower risk of incident CVD, CVD and all-cause mortality.[5–7] Studies on the specific relationship between walking and the risk of developing HF are extremely limited. We previously published results of a 14-year follow-up on 137,303 multiethnic older women and showed significant inverse associations of walking volume with risks of HF and its sub-types, after controlling extensively for confounding including total PA levels.[8] However, we did not evaluate the unique role of walking pace in this previous study. Postmenopausal women and racial-ethnic minorities are disproportionately affected by the burden of HF[1]and physical inactivity, [9]and yet under-represented in most previous studies on PA and HF risk.[2] Lack of time is frequently cited as the primary barrier to meeting current recommendations regarding physical activity.[10] If brisk walking for a shorter duration (frequency X time per bout) provides similar benefit as walking at a slower pace but for a longer duration, then PA recommendations may suggest such a strategy to improve health outcomes. This could be particularly relevant among older adults who often are not capable of safely engaging in other types of activities at higher intensity, but who are able to participate in walking and gradually increase their walking pace.[11] Understanding of the potential role of walking pace in the development of HF and its subtypes in later life could provide the opportunity to refine PA recommendations as part of primary HF prevention for older adults. In this prospective study, we examined associations of walking pace with overall HF and its subtypes adjusting for walking duration (hours/week) and non-walking PA among the Women's Health Initiative (WHI) participants.

METHODS

Study Population

The WHI includes 161,808 postmenopausal women aged 50 to 79 years recruited from 40 clinical centers in the United States between 1993 and 1998. Details of the recruitment, baseline assessments, and follow-up have been published previously[12,13,14] In 2010, a sub-cohort of 44,174 participants, oversampled for African American and Hispanic/Latina women, were evaluated both retrospectively and prospectively until March 31, 2018 for incident hospitalized HFpEF and HFrEF events by trained physician adjudicators.[15] After excluding participants who at WHI enrollment had a history of HF, cancer, or severely limited ability to walk one block due to health as well as those who reported walking never or rarely at baseline, the final analytical sample included 25,183 postmenopausal women for

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the current analysis (shown in the Supplementary Figure S1). The baseline characteristics of those with missing walking pace are available in the Supplementary Table S1.

Measures

The methods of baseline data collection in WHI [12–14] and validation of HF cases[8,15,16] have been published. At the baseline visit, participants completed self-administered questionnaires related to personal and family health histories, recreational PA, smoking, diet, and other behavioral and lifestyle-related factors. Clinical measurements, including height, weight, waist and hip circumferences, and blood pressure, were obtained by trained staff members. A detailed questionnaire was administered to collect data on different types of recreational PA (including strenuous, moderate, and mild activities).[17] Walking was assessed separately to the questions on recreational PA by a series of specific questions about the frequency of walks outside the home for more than 10 minutes without stopping, the average duration of each walk, and the usual walking pace (causal: less than 2 miles per hour; average: 2-3 miles per hour; fast: more than 3 miles per hour). Metabolic equivalent (MET) intensity values for specific activities were obtained from the Compendium of Physical Activities,[18] and assigned to each walking pace (casual 2 METs; average 3 METs; fast 4.5 METs). Total walking volume was calculated as the product of walking duration and frequency (hours/week) multiplied by the walking MET values, and summarized as MET-hours/week of walking activity. The validity and test-retest reliability of different PA measures in the WHI have been published.[19,20] Supplementary Figure S2 depicts how total recreational PA energy expenditure is created by different PA-related variables in WHI.

Ascertainment of Heart Failure

The WHI adjudication criteria for HF and its subtypes have been described in detail elsewhere.[15,16] Physician adjudicators reviewed hospital records of suspected HF cases for evidence of acute decompensated HF. Adjudication of hospitalized HF subtypes (HFpEF vs. HFrEF) was on the basis of measured ejection fraction (EF) at the time of HF diagnosis. HFrEF was defined as HF with an EF < 45% and HFpEF was defined as HF with an EF ≥ 45%. If no ejection fraction was available, it was classified as HF with unconfirmed ejection fraction and was not included in the present analysis. The acute HF classification system used in this analysis has been shown to have good agreement with other epidemiological HF algorithms.[21]

Statistical Analysis

Baseline participant characteristics were summarized according to walking pace categories (casual, average, and fast). Continuous variables are presented as the mean ± SD or median with interquartile range, and categorical variables are presented as frequencies and proportions. Differences in baseline characteristics across walking pace categories were tested by χ^2 tests for categorical variables and by analysis of variance (ANOVA) for continuous variables.

In the primary analysis, walking pace (casual [referent], average, and fast) at baseline was the exposure of interest and the incidence of HF, HFpEF, and HFrEF during follow-up were the outcomes of interest. Follow-up time for each participant was calculated from the date

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of study enrollment to the date of a confirmed incident HF event, last follow-up, death from any cause, or completion of the follow-up interval (March 31, 2018), whichever came first. Multivariable-adjusted Cox proportional hazards regression models were used to examine associations between walking pace and risk of HF, adjusting for age, WHI OS/CT indicator, ethnicity, region, education, income, smoking status, alcohol consumption, BMI, hormone therapy (HT) use, dietary alternative health eating index (AHEI) score, family history of premature myocardial infarction (MI), and history of hysterectomy. Non-walking PA volume (MET-hours/week) and the duration of walking (hours/week) were additionally included as a covariate in multivariable models in order to better isolate the contribution that walking pace has on HF risk, independent of non-walking PA and walking duration. Since diabetes mellitus, hypertension and dyslipidemia may be in the causal pathway, we only analyzed these covariates as potential confounders in sensitivity analyses. Kaplan-Meier curves were visually inspected to evaluate whether the proportionality assumption violated for walking pace categories; no appreciable violations were noted. Test for trend evaluated non-zero linear slope using median values for each category walking pace.

To ensure the robustness of our primary results, a series of sensitivity analyses were conducted by: 1) additional adjusting for the vigorous intensity PA (MET-hours/week), history of diabetes, history of hypertension, and history of hypercholesterolemia; 2) excluding participants with prevalent CVD at baseline; 3) excluding participants with a low physical functioning score constructed from the Rand 36-Item Health Survey (Rand-36; scored 0-100 with higher scores reflecting better function) as slow walking pace has been associated with low levels of self-reported physical function and frailty ; and 4) excluding incident HF cases identified during the first 3 years of follow-up. The latter three of these sensitivity analyses were to address the possibility of reverse causation conferred by the presence of subclinical disease, and related poor physical function at baseline beyond the baseline exclusions of those who reported the inability to walk one block due to health or those who reported no walking behavior.

To compare the importance of walking pace among those with shorter walking durations per week, we defined nine combinations of walking pace (3 levels) and duration (3 levels), and calculated the hazard ratios of each combination compared with the slowest, shortest walking profile (casual walking with less than 1 hour/week duration) as the reference, using the same multivariable adjusted model.

RESULTS

Cohort Characteristics

At baseline, the mean age of all study participants was 62.6 (sd=7.2) years, 56% of participants were white, 28% were black, 14% were Hispanic, and 2% were of other non-specified race and ethnic groups. Compared with women who reported casual walking pace, those who reported walking at a fast pace were, on average, younger, higher proportion of Caucasian race-ethnicity, had lower BMI and blood pressures, higher physical functioning scores and total recreational PA, and slightly higher diet quality scores (Table 1). These women also had a lower history of hysterectomy and lower prevalence of diabetes, hypertension, hypercholesterolemia, and family history of MI.

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Associations between walking pace and risk of total hospitalized HF

During a median follow-up of 16.9 (IQR=11.7) years, we identified 1455 newly diagnosed and adjudicated cases of acute decompensated hospitalized HF with available data on walking pace, including 811 cases of HFpEF, 429 cases of HFrEF, and 215 cases of unknown EF. Walking pace was a strong predictor of the subsequent risk of hospitalized HF (Table 2). After adjusting for age, WHI OS/CT indicator, race/ethnicity, region, education, income, smoking status, alcohol consumption, BMI, HT use, AHEI score, family history of MI, and history of hysterectomy, non-walking PA, and walking duration (hours/week), walking pace was significantly associated with risk of hospitalized HF in an inverse and graded manner ($P_{trend} < 0.001$). Across incremental categories of walking pace (casual, average, fast), the HR was 1.00 (referent), 0.73 (95% CI: 0.65, 0.83) and 0.66 (95% CI: 0.56, 0.78).

Associations between walking pace and risk of hospitalized HFpEF and HFrEF

After controlling for the same covariates as above, a significant inverse dose-response relationship was also observed between walking pace categories and hospitalized HFpEF (Table 2). Compared with casual walkers, women who walked at an average or fast pace had HRs for HFpEF of 0.73 (95% CI: 0.62, 0.86) and 0.63 (95% CI: 0.50, 0.80), $P_{trend} <0.001,$ respectively. The multivariable-adjusted association with hospitalized HFrEF comparing the average walking to casual walking pace was also statistically significant (HR=0.72, 95% CI: [0.57, 0.91]). There was a borderline significant difference observed between those who walked at a fast compared with casual pace (HR=0.74, 95% CI: [0.54, 0.99], and the P_{trend} =0.031 was also significant. Supplementary Figure S3 shows Kaplan-Meier estimated survival curves for HF and HF subtypes, based on walking pace.

Sensitivity analyses

To account for vigorous intensity PA other than fast walking, we additionally adjusted for total volume of vigorous PA. In the same sensitivity analysis, we also adjusted for potential confounding by diabetes, hypertension and dyslipidemia, which could be on the causal pathway between walking pace and HF. As shown in Table 3, walking pace remained significantly associated with the risk of incident acute hospitalized overall HF, HFpEF in an inverse and graded fashion, similar to what was observed in the primary analysis, but a significant inverse association with hospitalized HFrEF was not observed.

To reduce the likelihood of reverse causality, we excluded prevalent CVD cases and those developing HF in the first three years of follow-up in separate sensitivity analyses and found similar results as the primary analysis (Table 3). As slow walking pace is also associated with low physical function and frailty, we performed additional sensitivity analyses, where we excluded those participants with low physical functioning score (Rand-36 physical functioning score <60) and found similar results for total hospitalized HF and HFpEF (Table 3).

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Joint associations between walking duration and walking pace with total hospitalized HF, HFpEF, and HFrEF

To better understand the unique contribution of walking pace in conjunction with different walking durations, we evaluated the joint association of walking pace and duration with HF and its subtypes. Using casual walking pace with the shortest walking duration of less than 1 hour/week as the reference group, we observed significantly lower risk of total HF, HFpEF, and HFrEF for the average and fast pace walking participants even with the same walking duration (Figure 1).

As we expected, fast walking with longest walking duration (>2 hours/week) had the lowest hazard rate among the nine possible joint groups with regard to HF, HFpEF, and HFrEF. However, the most interesting finding was that in comparison with duration, walking pace seems to be a stronger predictor for HF and its subtypes; fast walking groups (even those with a walking duration of less than 1hour/week) were associated with lower hazard ratios than almost all the remaining groups, particularly with regard to total HF and HFpEF.

DISCUSSION

Among a large multi-racial cohort of postmenopausal women, an inverse graded relationship with walking pace was found for both acute hospitalized overall HF and HFpEF. In our previous study within the WHI[8] a strong significant inverse association between walking volume (met-hours/week) and HF incidence was observed. However, these earlier results did not evaluate the unique role of walking pace. Other studies on walking pace and cardiovascular outcomes provide corroborating evidence.[5,19] In the UK Biobank study[26], women walking at a fast pace (>4 mph, as in our study) when compared with women defined as slower walkers, had a 27% and 20% lower multivariable risk of all-cause and CVD mortality, respectively, adjusting for total walking duration and total physical activity. Indeed, slow walking pace both objectively measured and self-reported has been associated with increased risk of mortality, incident disability, and poor physical functioning.[22–26] Two studies drawn from the Copenhagen Heart Study[27] and the Cardiovascular Heart Study[28] found an inverse relationship between the walking pace and risk of HF. While the majority of their study populations were non-Hispanic whites, the current study has a larger sample size (two and four times, respectively) and more racially-ethnically diverse study population. Also, to our knowledge, the present investigation is the first large prospective study to assess the association of walking pace and the risks of incident HFpEF and HFrEF, and to do so with a focus on older postmenopausal women who typically have been understudied in this topic area. Collectively, these studies support the notion that walking pace is a key dimension of human walking behavior in relationship to health benefits (here HF risk) and should be considered in the development of updated PA guideline recommendations and the design of future lifestyle interventions targeted toward optimizing cardiovascular health, and HF prevention, in later life. Sarcopenia—loss of muscle mass in association with weakness and diminished PA in severe cases—is associated with slow walking pace and increased risk of HF especially HFpEF.[29] It has been shown that higher PASE (Physical Activity Scale Elderly) is associated with higher muscle mass and strength; and, PASE score in addition to the evaluation of muscle mass and strength enable us to identify older adults who are at

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high-risk of sarcopenia.[30] Also, in a recently published paper by Konishi et al., sarcopenia was shown to be an independent predictor of 1-year mortality in both HFpEF and HFrEF [hazard ratio 2.42 (1.36-4.32) for HFpEF and 2.02 (1.08-3.75) for HFrEF].[31] Therefore, sarcopenia is likely to be a mediator between walking pace and HF, especially HF prognosis and mortality.

Based on the results of the joint association of walking pace and duration with incident HF, we observed that average-paced walking even with relatively shorter durations was consistently associated with lower hazard ratios than casual walking pace with longer durations. Therefore, while fast pace might be physically out of reach for a large number of older postmenopausal women, achieving the average pace may be helpful for this population, and make the case for targeted interventions like group walking classes. The LIFE clinical trial study[32] (Lifestyle Interventions and Independence for Elders) had an intervention arm with a goal of achieving 150 minutes/week of moderate-intensity walking. While it did not include HF as an outcome, no significant improvement on other cardiovascular outcomes were found. However, the average age of its participants was 79±5 years old, with less than four years of follow-up. In comparison, our current study's average age at baseline was approximately 63 years old, with a median follow-up of 16.9 years. That is why we believe that we still need to conduct physical activity intervention trials, or in the meantime, hypothetical interventions on large longitudinal observational data by using modern causal inference methods.

A study in the UK Biobank demonstrated a strong dose-response relationship between walking pace and maximal oxygen uptake·[26] among 26,593 women, aged 39-73 years, age-adjusted mean maximal oxygen uptake was 28.1 mL/kg/min for women reporting slow walking pace (mph were not given), 30.9 mL/kg/min for steady/average pace walkers, and 34.0 mL/kg/min among brisk walkers (trend $p < 0.001$). These results imply that walking pace may be an important marker of one's cardiorespiratory fitness, which has been shown to be inversely associated with HF incidence in women.[33] We attempted to control for the influence of differences in physical functioning in the present analysis on walking pace and HF risk using several approaches. Women who self-reported inability to walk one block unassisted were excluded from the analytic cohort for the present study. We conducted analyses stratifying on RAND36 physical functioning score, as well as sensitivity analysis that excluded women with low RAND36 scores. Results were consistent in showing an inverse association between walking pace and risk of overall HF and HFpEF.

Strengths of the present study include the prospective design, the large sample size, diverse cohort, detailed assessment of walking traits, long-term follow-up, adjudicated acute decompensated hospitalized HF data, adjustment for a large number of confounders including non-walking recreational PA, and availability of data on HF subtypes. Additionally, in the sensitivity analysis, we adjusted for several potential mediators. Therefore, our analyses provide relatively conservative estimates of the association between walking pace and HF, suggesting actually even greater potential benefits could be related to walking.

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There are also several potential limitations. First, although the study population was of more diverse racial-ethnic and social background than most previous studies, it consists of only postmenopausal women, which may limit generalizability. Another major limitation is the measurement error that was inevitably involved in the assessment of walking-related traits using questionnaires. While our physical activity measures including walking pace and duration were self-reported, the instrument used in WHI has been shown to have reasonably high reproducibility.[19] Given the prospective study design in which walking exposures were self-reported prior to HF diagnosis, exposure misclassification would most likely be non-differential and estimated associations would be biased towards the null. Additionally, since initial ascertainment of HFpEF and HFrEF cases was based upon self-reported hospitalization, this could have resulted in some missed cases of outpatient HF. However, outpatient diagnosed HF is less than 25% of HF, is equally distributed between HFpEF and HFrEF, and leads to subsequent hospitalization within a relatively short period of time.[34] In addition, ejection fraction information, while captured in the majority of HF outcomes among the women in the sub-cohort where EF was classified, was missing in 17%, leading to potential misclassification bias. We excluded these individuals from our HF subtype analysis. This bias is likely non-differential and would be expected to bias our results towards the null.

CONCLUSION

Among a large and diverse cohort of postmenopausal women, faster walking pace was associated with lower risks of incident acute decompensated hospitalized HF, HFpEF, and HFrEF. These findings suggest that a slow walking pace may help to identify those at higher risk of HF and that walking at a faster pace may be associated with improved cardiovascular health for postmenopausal women,[6,7] here extending to HF, even with less than 1 hour/week walking duration. Slow walking pace may help to identify those at higher risk of HF who may benefit from targeted interventions to increase cardiorespiratory fitness and enhanced exercise tolerance. Randomized controlled primary HF prevention trials are needed to confirm our findings and to determine the safety profile of fast compared with slow walking in older ages. Future design of PA intervention programs should take into account the important role of walking pace for improving and maintaining cardiovascular health in older adults.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Key Points:

- Walking pace was inversely associated with risks of overall HF, HFpEF, and HFrEF in postmenopausal women.
- The risk of incident HF among fast walkers with a walking duration of less than 1 hour/week was equal to or lower than the risk of HF among walkers with casual or average pace who had reported 1-2 hours and more than 2 hours walking per week.

Why does this matter?

From a geriatrician viewpoint, slow walking pace may help to identify those at higher risk of HF who may benefit from targeted interventions to increase cardiorespiratory fitness and enhanced exercise tolerance. From a preventive viewpoint, if our finding—fast walking compensates for relatively shorter durations of walking with regard to the risk of incident HF—is proven to be causal by randomized trials, there will be an opportunity for those who do not have enough time or motivation to walk as long as the guidelines recommend to still reduce their HF risk by increasing their walking pace when capable of doing so.

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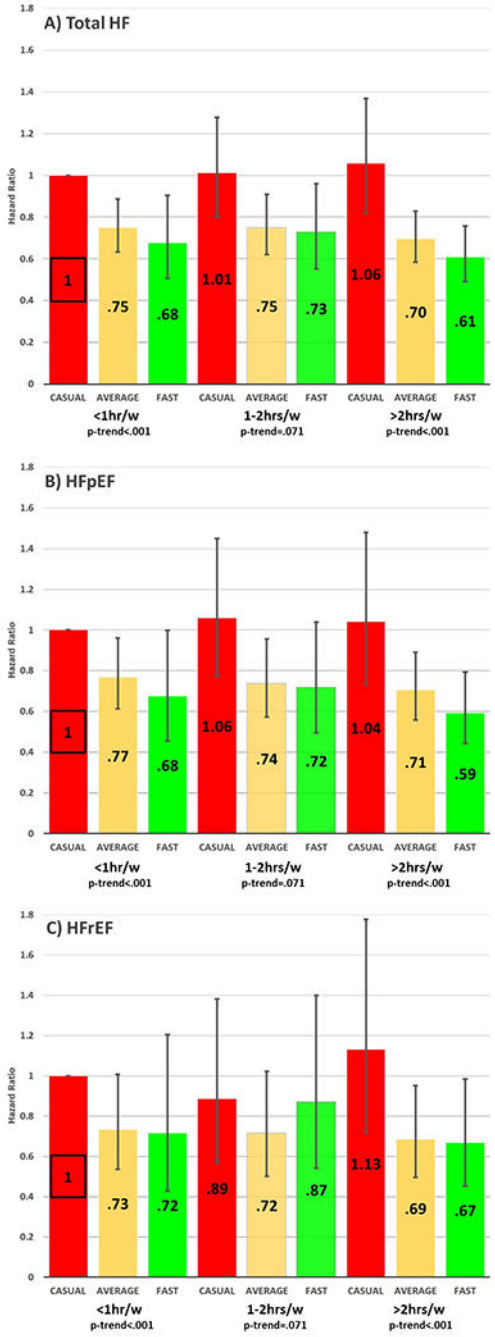

Figure1.

Joint association of walking pace and duration with incident HF. Casual walking pace with walking duration<1 hour/week is the reference group. As expected, fast walking with longest walking duration (>2 hours/week) had the lowest hazard rate. Compared to walking duration, walking pace seems to be a stronger predictor for incident HF. Average and fast walking even with short walking duration were associated with lower hazard ratios than casual walking pace with longer durations.

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Table 1.

Baseline characteristics of analysis sample (N=25,183) according to walking pace categories.

	Casual (<2mph) N=6,266	Average (2-3 mph) N=12,764	Fast (>3 mph) N=6,153	p-value
Age, mean (SD), year	62.8 (7.2)	62.9 (7.2)	61.6 (6.9)	<.001
Ethnicity, No. (%)				
Black	2,389 (38.1)	3,153 (24.7)	1,599 (26.0)	<.001
Hispanic	1,071 (17.1)	1,595 (12.5)	739 (12.0)	
Other	196 (3.1)	304 (2.4)	140 (2.3)	
White	2,610 (41.7)	7,712 (60.4)	3,675 (59.7)	
Body Mass Index, mean (SD), kg/m2	30.6 (6.4)	28.8 (5.7)	27.0 (5.0)	<.001
Alternative Healthy Eating Index (AHEI-2010), mean (SD)	49.7 (10.0)	52.4 (10.4)	55.2 (10.7)	<.001
Systolic blood pressure, mean (SD), mmHg	131.1 (17.6)	128.6 (17.6)	125.5 (17.3)	<.001
Diastolic blood pressure, mean (SD), mmHg	76.9 (9.4)	76.2 (9.2)	75.7 (9.0)	<.001
Physical functioning score (Rand-36), mean (SD)	78.4 (17.4)	85.9 (13.4)	91.3 (10.4)	<.001
Energy expenditure from total physical activity, mean (SD), MET-hr/wk	7.02 (9.34)	12.27 (12.25)	21.00 (17.36)	<.001
Proportion of total physical activity energy expenditure from walking, mean (SD)	0.51 (0.41)	0.54 (0.37)	0.58 (0.33)	<.001
Walking frequencies, No. (%)				
1-3 times/month	1,884 (30.1)	2,374 (18.6)	604 (9.8)	<.001
1 time/wk	1,087 (17.4)	1,652 (12.9)	480 (7.8)	
2-3 times/wk	1,847 (29.5)	4,561 (35.7)	1,981 (32.2)	
4-6 times/wk	964 (15.4)	3,126 (24.5)	2,351 (38.2)	
7 or more times/wk	484 (7.7)	1,051 (8.2)	737 (12.0)	
Usual walking bout duration, No. (%)				
Less than 20 min	2,950 (47.1)	3,193 (25.0)	813 (13.2)	<.001
20-39 min	2,508 (40.0)	6,255 (49.0)	2,744 (44.6)	
40-59 min	419 (6.7)	2,166 (17.0)	1,590 (25.8)	
1 hr or more	389 (6.2)	1,150 (9.0)	1,006 (16.4)	
Smoking, No. (%)				
Non-smokers	3,290 (53.3)	6,634 (52.5)	3,028 (49.7)	<.001
Past smokers	2,185 (35.4)	4,921 (38.9)	2,662 (43.7)	
Current smokers	699 (11.3)	1,087 (8.6)	409 (6.7)	
Alcohol, No. (%)				
Non-drinkers	948 (15.3)	1,540 (12.2)	626 (10.2)	<.001
Past drinkers	1,681 (27.1)	2,441 (19.3)	1,030 (16.8)	
Current drinkers	3,637 (58.0)	8,783 (68.8)	4,497 (73.1)	

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	Casual (<2mph) N=6,266	Average (2-3 mph) N=12,764	Fast (>3 mph) N=6,153	p-value
Education, No. (%)				
Less than college	4,566 (72.9)	8,073 (63.2)	3,591 (58.4)	<.001
College degree or higher	1,700 (27.1)	4,691 (36.8)	2,562 (41.6)	
Income, No. (%)				
Less than $20,000	1,786 (28.5)	2,432 (19.1)	833 (13.5)	<.001
$20,000 to $74,999	3,568 (56.9)	8,073 (63.2)	3,927 (63.8)	
$75,000 or more	535 (8.5)	1,557 (12.2)	1,051 (17.1)	
Unknown/refused	377 (6.0)	702 (5.5)	342 (5.6)	
Diabetes, No. (%)	586 (9.4)	678 (5.3)	190 (3.1)	<.001
Hypertension, No. (%)	2,741 (43.7)	4,525 (35.4)	1,678 (27.3)	<.001
Hypercholesterolemia, No. (%)	1,007 (16.1)	1,810 (14.2)	714 (11.6)	<.001
Hormone replacement therapy, No. (%)				
Never used	3,112 (49.8)	6,084 (47.9)	2,721 (44.4)	<.001
Past user	1,952 (31.3)	4,247 (33.4)	2,004 (32.7)	
Current user	1,182 (18.9)	2,372 (18.7)	1,403 (22.9)	
Hysterectomy, No. (%)	2,827 (45.12)	5,124 (40.2)	2,237 (36.4)	<.001
Family history of MI, No. (%)	682 (10.9)	1,400 (11.0)	6334 (10.3)	<.001

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Table 2.

Rates and relative risks of HF and HF subtypes according to categories of walking pace (N=25,183).

Walking Pace	Number of cases	Incidence Rate[a]	Hazard Ratio (95%CI)			
			Model 1	Model 2	Model 3	Model 4
Total HF						
<2 mph	454	52.3	1.00	1.00	1.00	1.00
2-3 mph	739	37.9	0.62 (0.55, 0.70)	0.72 (0.63, 0.81)	0.72 (0.64,0.82)	0.73 (0.65,0.83)
>3 mph	262	26.2	0.48 (0.41, 0.56)	0.63 (0.54,0.75)	0.64 (0.55,0.76)	0.66 (0.56,0.78)
P-trend	-	-	<.001	<.001	<.001	<.001
HFpEF						
<2 mph	246	28.3	1.00	1.00	1.00	1.00
2-3 mph	421	21.6	0.63 (0.53, 0.73)	0.72 (0.61,0.85)	0.72 (0.61,0.85)	0.73 (0.62,0.86)
>3 mph	144	14.4	0.46 (0.38, 0.57)	0.62 (0.50,0.77)	0.63 (0.50,0.78)	0.63 (0.50,0.80)
P-trend	-	-	<.001	<.001	<.001	<.001
HFrEF						
<2 mph	136	15.7	1.00	1.00	1.00	1.00
2-3 mph	206	10.6	0.62 (0.49,0.77)	0.70 (0.56,0.88)	0.71 (0.57,0.89)	0.72 (0.57,0.91)
>3 mph	87	8.7	0.56 (0.43,0.74)	0.70 (0.52,0.94)	0.72 (0.54,0.97)	0.74 (0.54,0.99)
P-trend	-	-	<.001	.010	.018	.031

Model 1: includes study component (WHI OS or CT), region, age and race-ethnicity.

Model 2: Model 1 + education, income, alcohol consumption, smoking status, BMI, hormone therapy (HT) usage status, alternative health eating index (AHEI), family history of MI, history of hysterectomy.

Model 3: Model 2 + non-walking physical activity.

Model 4: Model 2 + non-walking physical activity + walking duration (hours/week).

[a]Per 100,000 person-years

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Table 3.

Sensitivity analyses of the associations of walking pace with Total HF, HFpEF, and HFrEF

Walking Pace	Number of Cases	Incidence Rate[a]	HR[b] (95% CI)	P-trend
Adjusting for vigorous PA, prevalent diabetes, hypertension and hypercholesterolemia (N=25,183)				
Total HF				
Casual (<2 mph)	454	52.2	1.00	<.001
Average (2-3 mph)	739	37.9	0.77 (0.68, 0.87)	
Fast (>3 mph)	262	26.2	0.71 (0.59, 0.84)	
HFpEF				
Casual (<2 mph)	246	28.3	1.00	<.001
Average (2-3 mph)	421	21.6	0.77 (0.65, 0.91)	
Fast (>3 mph)	144	14.4	0.68 (0.54, 0.86)	
HFrEF				
Casual (<2 mph)	136	15.7	1.00	.077
Average (2-3 mph)	206	10.6	0.74 (0.59, 0.94)	
Fast (>3 mph)	87	8.7	0.78 (0.57, 1.07)	
Excluding prevalent CVD cases (N=24,297)				
Total HF				
Casual (<2 mph)	404	48.5	1.00	<.001
Average (2-3 mph)	663	34.9	0.72 (0.63, 0.82)	
Fast (> 3 mph)	242	24.7	0.65 (0.55, 0.78)	
HFpEF				
Casual (<2 mph	216	25.9	1.00	<.001
Average (2-3 mph)	391	20.6	0.75 (0.63, 0.90)	
Fast (>3 mph)	134	13.7	0.64 (0.50, 0.81)	
HFrEF				
Casual (<2 mph)	122	14.6	1.00	.016
Average (2-3 mph)	174	9.2	0.66 (0.51, 0.84)	
Fast (>3 mph)	78	7.9	0.70 (0.50, 0.96)	
Excluding participants with low physical functioning[c](N=23,303)				
Total HF				
Casual (<2 mph)	357	47.4	1	<.001
Average (2-3 mph)	669	36.1	0.74 (0.65, 0.85)	
Fast (>3 mph)	254	25.9	0.69 (0.57, 0.82)	
HFpEF				
Casual (<2 mph)	199	26.4	1	<.001
Average (2-3 mph)	388	20.9	0.72 (0.60, 0.87)	
Fast (>3 mph)	138	14.1	0.63 (0.49, 0.80)	
HFrEF				
Casual (<2 mph)	108	14.3	1.00	.132
Average (2-3 mph)	184	9.9	0.73 (0.57, 0.95)	

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Walking Pace	Number of Cases	Incidence Rate[a]	HR[b] (95% CI)	P-trend
Fast (>3 mph)	85	8.7	0.79 (0.57, 1.09)	
Excluding the first three years of follow-up (N=24,354)				
Total HF				
Casual (<2 mph)	411	47.5	1.00	<.001
Average (2-3 mph)	684	35.2	0.73 (0.64, 0.83)	
Fast (>3 mph)	253	25.3	0.68 (0.57, 0.81)	
HFpEF				
Casual (<2 mph)	229	26.5	1.00	<.001
Average (2-3 mph)	396	20.4	0.72 (0.61, 0.86)	
Fast (>3 mph)	142	14.2	0.65 (0.51, 0.82)	
HFrEF				
Casual (<2 mph)	118	13.6	1.00	.111
Average (2-3 mph)	191	9.8	0.75 (0.59, 0.96)	
Fast (>3 mph)	84	8.4	0.79 (0.58, 1.08)	

[a] Per 100,000 person-years.

[b] Model is adjusted for age, OS/CT indicator, ethnicity, region, education, income, smoking status, alcohol consumption, BMI, hormone therapy (HT) usage status, alternative health eating index (AHEI), family history of MI, history of hysterectomy, non-walking physical activity, and walking duration (Same as Model 4 in Table 2).

[c] Low physical functioning defined as having a Rand-36 physical functioning score < 60.