ORIGINAL RESEARCH

Can Older Women Self-Select Walking Speeds Congruent With Optimal Health Outcomes?

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ABSTRACT

Background: We sought to determine if women (65–74 y) can self-select an exercise intensity during walking commensurate with current physical activity recommendations.

Methods: Thirteen healthy older women (age = 68 ± 3 y, body mass index = 25.7 ± 4.9 kg·m^{-2}, peak O_2 uptake = 24.1 ± 4.5 mL·kg^{-1}·min^{-1}) performed 4 30-min walking trials (2 × treadmill [TM], 2 × overground [OG]) in a counterbalanced, randomized order. For the first walking trials (i.e., TM_1 and OG_1), participants self-selected walking pace. Walking speed, heart rate (HR) and ratings of perceived exertion (RPE) were recorded. For the second trials for each mode (i.e., TM_2 and OG_2), walking speed was controlled to match speeds selected during TM_1 and OG_1, and pulmonary gas exchange, HR, and RPE were measured.

Results: Exercise intensity was within current guidelines: OG = 70% HRpeak, 95% confidence interval (CI) = 61–75%; TM = 66% HRpeak, 95% CI = 63–74%. Significant increases in HR and walking speed were observed during OG (HR $P = 0.005$, walking speed $P = 0.001$) compared with TM; O_2 uptake during OG was significantly greater than TM for first 15 min exercise.

Conclusion: Healthy women can self-select intensity during walking commensurate with current physical activity recommendations. *Journal of Clinical Exercise Physiology*. 2019;8(1):13–20.

Keywords: exercise, intensity, physical activity, treadmill, overground

INTRODUCTION

The American College of Sports Medicine (ACSM), American Heart Association (AHA), British Heart Foundation, and Exercise and Sports Science Australia recommend that older adults engage in 150–300 min/wk of physical activity, such as walking, to maintain good health. Less well defined is the intensity at which an individual should perform physical activity, although moderate-intensity exercise has been widely promoted as part of the recommended exercise prescription. The ACSM has classified moderate-intensity cardiorespiratory endurance exercise as 64–76% of an individual's maximum heart rate (HR) or 46–63% of an individual's peak O_2 uptake (1–3), whereas the AHA defined moderate-intensity physical activity as 50–69% of maximal HR or 45–59% of peak O_2 uptake (4). While maximal exercise is not in the best interests of the older person due to the increased risk of medical events, including acute cardiovascular events, the estimation of exercise intensity is typically based on percent of maximal HR or peak O_2 uptake (5,6).

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It may be simple enough to prescribe and achieve the recommended relative exercise intensities equivalent to 64–76% of peak HR and 46–63% of peak O_2 uptake in an organized and well-equipped center-based physical activity program. However, many individuals engage in home-based, self-directed physical activity, where exercise intensity (e.g., walking speed) is self-selected. This is particularly evident among older individuals who may exercise in the home or community due to economic, accessibility, and/or other barriers (7). However, without specialized equipment and/or appropriate education, it may be difficult for many individuals to select an appropriate exercise intensity that is safe and ensures beneficial health outcomes. Indeed, achieving the recommended exercise intensity may be more important than exercise duration for the consolidation of long-term health benefits, such as the reduced risk and improved management for many chronic diseases (8).

Two studies reported that self-selected walking speed may result in exercise intensities that approach those outlined by the ACSM (9,10). However, both of these studies have methodological deficiencies that prevent the findings from being broadly adopted for community- or home-based exercise prescription in the elderly: neither study directly measured O_2 uptake during overground (OG) walking. Rather, both studies derived O_2 uptake estimates from a treadmill (TM) walking test performed at the same speed as that observed during OG walking. Using O_2 uptake measurements obtained during TM tests to estimate the exercise intensity of OG walking is problematic, as walking pattern has been demonstrated to differ between these 2 modes of walking (11). Furthermore, the inclusion of men and women, as well as participants from a wide age range, adds to the uncertainty for using self-selected walking speed for exercise prescription purposes in a discrete subgroup of the population.

Women aged 65 y and older are currently the fastest growing portion of the population, the most sedentary (12,13), constitute the greatest proportion of recreational walkers in Australia (14), and potentially have the most to gain from undertaking regular physical activity (15,16). Further research specific to facilitating evidence-based physical activity of older women is therefore warranted. The purpose of our study was to determine if healthy older women (65–74 y) self-select a walking intensity that is within the current recommendations for moderate-intensity endurance exercise.

METHODS

Participants

Thirteen women aged between 65 and 74 y participated in this study. All participants had performed light-moderate physical activity in the past 14 d but were not meeting the national guidelines for physical activity, i.e., 150 min of moderate-intensity exercise per week. Participants were excluded if (1) they were currently taking any medication known to interfere with the exercise response; (2) they were unable to walk unaided for at least 30 min; or (3) their medical history, hematological results, resting electrocardiogram and/or basic spirometry indicated significant risk of a cardiac event or other adverse medical complication. All participants received approval to participate from their family physician. The study was approved by the Human Research Ethics Committees of Griffith University and Bond University, and all participants gave their written consent to participate in the present study.

Experimental Design

Participants were required to attend 1 familiarization session and 5 experimental sessions. Familiarization included (1) practicing mounting and dismounting the TM (Lode Valiant, AN Groningen, Netherlands); (2) using the TM speed controller to determine a comfortable walking speed that was subsequently used for the graded walking test; (3) becoming comfortable wearing the portable metabolic measurement system (K4b^2 COSMED, Rome, Italy); and (4) using the Borg rating of perceived exertion (RPE) scale (6–20). Overall RPE was used, as we did not anticipate arm fatigue during TM walking. We did not anchor RPE, as previous work has shown this to be unreliable (17). During the familiarization session, forced vital capacity maneuver was completed using an open-circuit spirometer (Ultima, Medical Graphics Corp., St Paul, MN) to confirm pulmonary function was within normal limits. The first experimental session was used to determine peak exercise values for walking during a graded TM-walking test to volitional fatigue. Experimental sessions 2, 3, 4, and 5 were completed at least 7 d later and were each separated by at least 4 d. Participants completed 2 30-min OG walking trials, and 2 30-min TM walking trials. The first walking trial for each condition (i.e., OG trial 1 [OG_1], and TM trial 1 [TM_1]) were randomly ordered and required participants to walk for 30 min at a self-selected speed. If participants questioned the instruction, the statement was again repeated and the term “exercise” emphasized. No further instruction was given.

During the subsequent walking trials for each condition (i.e., OG_2 and TM_2), participants were required to walk at the predetermined walking speed (measured during OG_1 and TM_1) wearing the portable metabolic measurement system for the measurement of O_2 uptake. The order of OG_2 and TM_2 was randomized.

Experimental Exercise Tests

Determination of Peak Exercise Values

The graded TM-walking test commenced with 4 min of walking at 3.0 km·h^{-1} (1.86 mph) and 0% grade. Treadmill speed was then increased by 0.5–1.0 km·h^{-1} (0.31–0.62 mph) each minute until the participant’s predetermined preferred TM walking speed was attained. Thereafter, TM grade was increased by 2% every minute until the participant was unable to maintain the required intensity and requested to stop despite verbal encouragement. Gas exchange and ventilatory parameters were measured breath-by-breath using the portable metabolic measurement system, and cardiac rate and rhythm were monitored continuously using a 12-lead

TABLE 1. Participant characteristics, resting blood pressure, and spirometry values of women 65–74 y.

Variable	Mean ± SD
Age (y)	68 ± 3
Height (m)	1.63 ± 0.05
Body mass (kg)	68.4 ± 13.5
SBP (mm Hg)	128 ± 16
DBP (mm Hg)	78 ± 6
FVC (% pred.)	99 ± 13
FEV_1 (% pred.)	103 ± 19
FEV_1/FVC (%)	78 ± 5

SBP = systolic blood pressure; DBP = diastolic blood pressure; FVC = forced vital capacity as a percentage of age predicted maximum (i.e., % pred.); FEV_1 = forced expiratory volume in 1 s

electrocardiogram (CardioPerfect, Welch Allyn Inc., Skaneateles Falls, NY). The breath-by-breath gas exchange and ventilatory parameters were averaged over 30-s intervals, and peak exercise values reported as the average of the highest 2 30-s values recorded during the exercise test. The ventilatory threshold (VT) was determined using the modified V-slope method (18).

Experimental Walking Trials

Participants were able to self-select their walking speed during the first 2 30-min trials. During OG_1 and TM_1, participants were instructed to “walk at a speed you deem appropriate for 30 min of exercise.” No other encouragement or discussion about walking speed during the trial was provided.

Overground walking was conducted around an 83.5 m (274 ft) elliptical indoor track. Walking speed during OG_1 was measured twice per lap over 2 straight sections (16 m; 52.5 ft) of the track using timing lights (SMARTSPEED, Fusion Sport, QLD Australia). The 16-m monitoring sections were specifically chosen as the middle portion of a 26-m straight section of track; thus, each 16-m monitoring section included a 5-m “lead-in” and 5-m (16.4 ft) “lead-out” section of straight walking track.

Treadmill walking during TM_1 was performed at 0% gradient, and participants could increase and/or decrease the TM speed as often as desired throughout the trial. Treadmill speed was recorded continuously from an external control panel, which was blinded to participants.

The OG_2 and TM_2 walking trials were conducted in the identical manner except that participants were required to maintain the walking speed observed in the OG_1 and TM_1 walking trials while pulmonary gas exchange was measured using the portable metabolic system. Walking speed was achieved by either direct control of the TM belt speed by the investigators or by verbal instructions based on the time taken to complete each 16-m section of the OG track.

Heart rate was measured continuously during all 4 walking trials using a HR belt and recorder (Suunto T6, Vantaa, Finland), and RPE was recorded for both chest (cardiac/respiratory exertion) and legs (local muscle fatigue) every 5 min. Data from the walking sessions were averaged over 5-min periods, with the first 5 min of each exercise trial considered a transition period and excluded from the analysis. Walking intensity was expressed in absolute terms (using O_2 uptake, HR, and RPE values) and also expressed relative to the peak exercise values attained during the incremental exercise test (i.e., peak HR% and peak O_2 uptake%). Individual walking economy was also calculated by dividing O_2 uptake by mean walking speed (i.e., $mL \cdot min^{-1}/m \cdot min^{-1} = mL \cdot m^{-1}$).

Statistical Analysis

Statistical analysis was conducted using IBM SPSS statistics 19.0 software suite (SPSS, Chicago, IL). Shapiro-Wilk tests confirmed normality prior to analyses. Full-factorial analysis of variance was used to ascertain if there were any trial differences in walking speed, HR, and/or RPE between trials within each walking mode (i.e., OG and TM). As no differences were found between trials for both modes, all further analyses for walking speed, HR, and RPE were conducted on data obtained from TM_2 and OG_2. Comparisons between walking modes were also conducted across the following time intervals using analyses of variance (5–10, 10–15, 15–20, 20–25, and 25–30 min). Where significant *F* values were observed, least significant difference post hoc tests were performed. Statistical significance was set at 5% ($\alpha = 0.05$). Relations between the variables were assessed using Pearson product-moment correlation coefficient.

RESULTS

Table 1 presents the participant characteristics including their blood pressure and pulmonary function results obtained while at rest. The peak exercise values obtained during the graded TM-walking test are presented in Table 2. Values obtained for lung function were within expected ranges, and peak O_2 uptake was commensurate with apparently healthy older women reported elsewhere (19).

Values obtained during TM and OG walking are listed in Table 3. The 95% confidence intervals (CIs) for

TABLE 2. Peak exercise values determined during graded treadmill walking in women 64–75 y.

Peak Exercise Values	Mean ± SD
Peak VO_2 ($L \cdot min^{-1}$)	1.61 ± 0.25
Peak VO_2 ($mL \cdot kg^{-1} \cdot min^{-1}$)	24.1 ± 4.5
VT (% of peak VO_2)	71 ± 7
Peak RER	1.19 ± 0.05
Peak HR ($b \cdot min^{-1}$)	161 ± 11

VO_2 = oxygen uptake; VT = ventilatory threshold; RER = respiratory exchange ratio

TABLE 3. Values obtained during overground (OG) and treadmill (TM) walking in older women aged 65–74 y. Values are mean ± SD.[a]

Variable	OG		TM	
	Trial 1	Trial 2	Trial 1	Trial 2
Walking speed ($km•h^{-1}$)	5.77 ± 0.69	5.77 ± 0.71	4.93 ± 0.54	4.95 ± 0.55*
HR ($b•min^{-1}$)	112 ± 11	112 ± 10	107 ± 6	105 ± 9*
HR (% of HRpeak)	70 ± 8	70 ± 9	67 ± 7	66 ± 8*
VO_2 ($L•min^{-1}$)		1.07 ± 0.25		0.99 ± 0.27*
VO_2 (% of peak VO_2)		67 ± 15		62 ± 15*
Economy ($mL•m^{-1}$)[b]		11.2 ± 2.5		12.0 ± 3.0*
RPE—chest		10 ± 2		10 ± 2
RPE—legs		10 ± 3		10 ± 2

HR = heart rate; VO_2 = O_2 uptake; RPE = rating of perceived exertion using the Borg RPE scale (6–20)
*$P < 0.05$, significant difference between OG and TM walking
[a]There were no differences between trials within a walking mode (i.e., T_1 vs T_2)
[b]Economy was calculated as O_2 uptake per meter walked and expressed as $mL \cdot m^{-1}$

self-selected walking intensity, when expressed as a percentage of HRpeak, were 61–75% for OG and 63–74% for TM walking. As a percentage of peak O_2 uptake, the 95% CIs were 58–76% for OG walking and 52–71% for TM walking. When the O_2 uptake values were calculated as a percentage of the participant's VT, the mean O_2 uptake during OG walking was 94% VT (95% CI = 82–107% VT), while during TM walking the mean O_2 uptake was 87% VT (95% CI = 74–100% VT).

The walking speed that was measured every 5 min for self-selected TM and OG walking is presented in Figure 1A. At each 5-min interval, the self-selected walking speed for OG was significantly faster than TM, whereby the difference in walking speed between the 2 modes during each 5-min exercise period (i.e., P1 to P5) were: P1 = 1.04 $km \cdot h^{-1}$, $P < 0.01$; P2 = 0.89 $km \cdot h^{-1}$, $P < 0.01$; P3 = 0.76 $km \cdot h^{-1}$, $P < 0.01$; P4 = 0.72 $km \cdot h^{-1}$, $P < 0.01$; and P5 = 0.63 $km \cdot h^{-1}$, $P < 0.01$.

The variation in walking speed (0.19 ± 0.26 $km \cdot h^{-1}$) observed during the 30-min walking session for OG (P1 to P5) was not significant ($P = 0.43$). In contrast, there was a significant increase in the mean walking speed (0.66 ± 0.45 $km \cdot h^{-1}$, $P < 0.01$) from the beginning to the end of TM. Analysis of consecutive 5-min intervals revealed that the walking speed during TM walking increased between P1 and P2 by 0.22 $km \cdot h^{-1}$ ($P = 0.045$), after which the variation between consecutive intervals (i.e., P2–P5) was not significant.

Mean HR (see Figure 1B) was higher for OG walking, when compared to TM walking ($P < 0.01$). The overall increase of 8 $b \cdot min^{-1}$ in HR (P1–P5) was significant for both conditions ($P = 0.03$), although the magnitude of change for OG walking was not significantly different to that observed for TM; thus, no interaction effect was observed for HR.

There was an interaction effect ($P = 0.030$) for O_2 uptake, with significant differences in mean O_2 uptake being detected between OG and TM walking at the time periods P1 (0.12 $L \cdot min^{-1}$, $P < 0.01$) and P2 (0.10 $L \cdot min^{-1}$, $P = 0.02$). For TM, there was an increase in O_2 uptake over the 30-min session between P1 to P5 of 0.8 $L \cdot min^{-1}$ ($P = 0.04$), although there was no change in O_2 uptake for OG (difference from P1 to P5 = 0.3 $L \cdot min^{-1}$). We found a difference in economy (O_2 uptake per meter walked) between OG walking (11.2 ± 2.5 $mL \cdot m^{-1}$) and TM walking (12.0 ± 3.0 $mL \cdot m^{-1}$; $P = 0.049$). The O_2 uptake expressed as a percentage of the participants VT was different for the 2 conditions ($P = 0.02$), where OG (94 ± 21%) was higher than TM walking (87 ± 22%).

Figure 2 illustrates the relation between peak O_2 uptake and the walking speed achieved during OG (left panel) and TM (right panel) trials. The relationship was moderate to strong when peak O_2 uptake was expressed relative to body mass and in absolute terms ($r = 0.72$; $P < 0.01$) during OG walking. No significant relation existed between peak O_2 uptake, expressed relative to body mass ($r = 0.25$; $P = 0.40$) or in absolute terms ($r = 0.38$; $P = 0.20$), and TM walking.

DISCUSSION

The salient findings of the present study are that healthy women aged 65–74 y (1) self-select a walking speed that induces a metabolic load approximating the VT during both OG (~94% VT) and TM (~87% VT) walking; (2) self-select a faster walking speed during OG walking, which induces an elevated cardiovascular and metabolic "load," when compared with TM walking; (3) demonstrate significantly lower O_2 cost per meter walked (i.e., improved economy) during OG walking, when compared with TM; and (4) self-select an OG walking speed that is positively related to their peak O_2 uptake (i.e., increased physiological functional capacity was associated with faster preferred OG walking speed), although no significant relationship was observed between preferred TM walking speed and peak O_2 uptake. Moreover, no medical events were observed during exercise and/or in the weeks

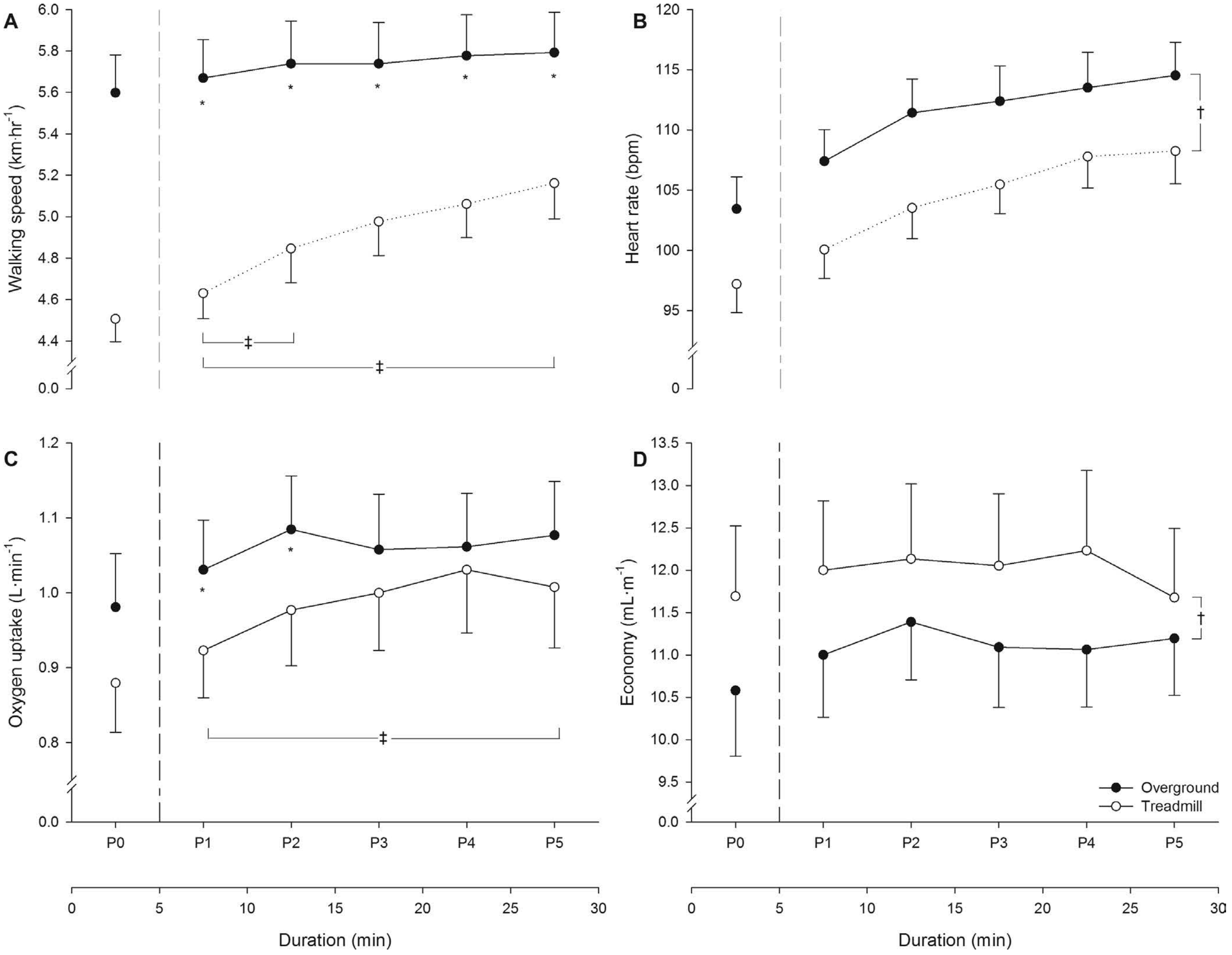

FIGURE 1. (A) Overground (OG) and treadmill (TM) walking speed, (B) heart rate, (C) O_2 uptake, and (D) movement economy (O_2 uptake per m walked). Data are presented for each discrete time period, represented by P1 (5–10 min), P2 (10–15 min), P3 (15–20 min), P4 (20–25 min), and P5 (25–30 min). Error bars indicate the standard error of the mean (SEM). The first 5 min of each 30-min walking trial (as indicated by the dashed line) was not included in statistical analysis. * denotes a significant difference between OG and TM walking for a given time period; ‡ denotes a significant difference between time periods during TM walking; † denotes a significant difference between the mean values for OG and TM walking.

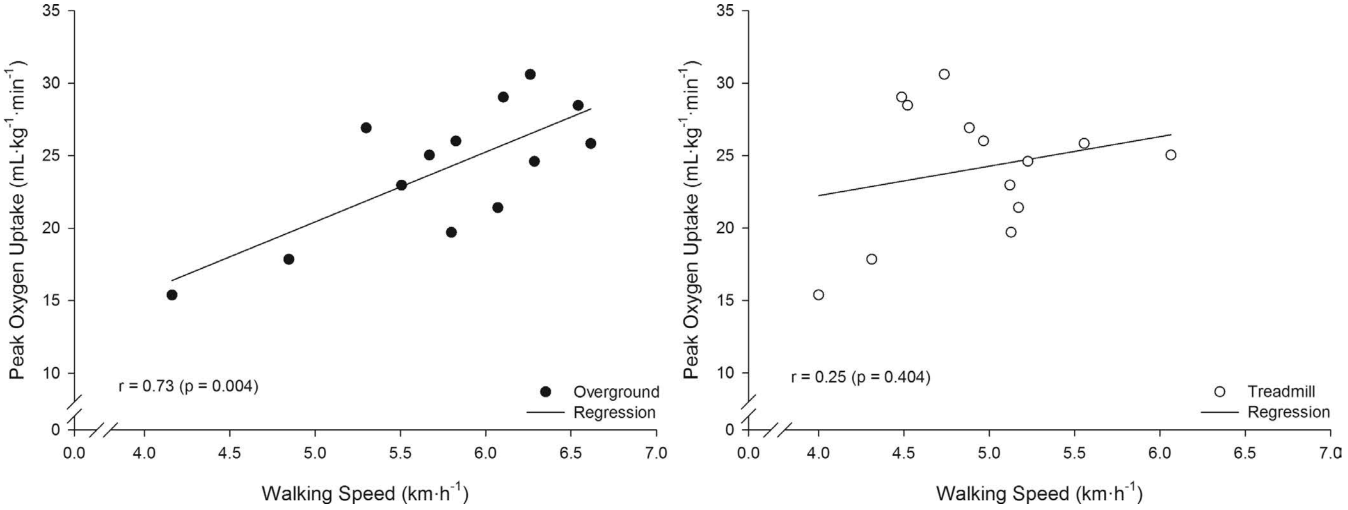

FIGURE 2. Peak O_2 uptake plotted against self-selected walking speed during overground and treadmill walking. Data points represent the mean walking speed (5–30 min) during Trial 2 for each condition. Solid line represents the linear regression of the data.

following the walking trials. The collective findings of this study support that older women self-select an exercise intensity during OG and TM walking that is commensurate with current recommendations for daily physical activity.

Regular physical activity across the lifespan contributes to healthy aging. Improved cardiorespiratory physiological functional capacity—perhaps the most evident benefit of endurance exercise training—is closely associated with decreased incidence of cardiovascular diseases, musculoskeletal and metabolic disorders, various cancers, and neurological dysfunction (5). Decreased burden of disease is not simply correlated with increased physiological functional capacity; rather, regular exercise induces beneficial causal adaptations at all levels of biological organization, from the organism to the regulation of gene expression (20,21). The accumulation of consistent findings demonstrating such health benefits has helped promote a worldwide initiative for using exercise prescription as an evidence-based method for the prevention and treatment of many chronic diseases (22). An important, yet often overlooked aspect of prescribing exercise to exercise-naïve (e.g., inactive older) individuals is that the associated health benefits of regular exercise may be achieved even among those who were previously and chronically sedentary. A prospective investigation of a large cohort of women aged over 65 y confirmed "conventional wisdom" that those who were active at study onset and remained active over the 5-y follow-up period had a much lower incidence of mortality from all causes when compared with those who were sedentary; however, the study also revealed that older women who became active between initial and follow-up testing shared remarkably similar reductions in all-cause mortality with those women who were always active (23). There is extensive evidence therefore that regular exercise across the lifespan is associated with healthy aging, and these benefits can be realized even when exercise training is first adopted later in life.

The principal barriers to the uptake and adherence to exercise prescription include a lack of awareness among the elderly of appropriate exercise prescription (i.e., intensity, duration) and the costs associated with using exercise facilities (24,25). Personal communications with our own participants (healthy women aged 65–74 y) provided the additional insight that many of these women felt "out of place" in formal exercise facilities (e.g., gymnasiums, health clubs) and thus had associated negative experiences, which supports earlier findings that the culture of exercise facilities is often a significant barrier to exercise participation (26). Given primary care providers prescribe home-based exercise programs that rely upon limited supervision and equipment (27), selection of an exercise-intensity for older adults based on simple and evidence-based methods is of value.

The present study demonstrated that, when healthy women aged 65–74 y are asked to perform walking at an "appropriate pace" for a 30-min exercise bout, they self-select an intensity that is known to confer the health benefits associated with regular exercise. On average, women in the present study walked OG at an intensity of 67 ± 15% of peak O_2 uptake, while TM walking was at a lower intensity (62 ± 15% of peak O_2 uptake). This difference in metabolic load was the result of an increased walking speed during OG when compared with TM walking. The OG walking intensity in the present study was higher than previously described as moderate-intensity exercise (46–63 and 45–59% of peak O_2 uptake) by the ACSM and AHA, respectively (4,5). When we expressed intensity relative to the VT—the most accurate demarcation between moderate- and heavy-intensity exercise—it was found that both TM and OG walking intensities were at the upper limit of the moderate-intensity domain (both ~90% of VT), which extends a similar finding in middle-aged (43 ± 5 y) and sedentary women (28). The capacity to perform exercise within the moderate-intensity domain without the need for specialized equipment is important for effective exercise prescription given there is minimal associated risk for cardiovascular events (29), and this intensity is reported to promote increased adherence to exercise training (30). These findings collectively suggest that older women self-select a walking speed that induces a metabolic load that is associated with established health benefits, is safe, and may facilitate increased exercise adherence.

The difference in self-selected speeds for TM and OG walking in the present study has possible implications when prescribing physical activity on TM compared to OG walking. Any walking speed or exercise intensity determined on a TM may not be appropriate for prescribing OG walking for health benefits and vice versa. For example, if walking speed was titrated on a TM based on an individual's physiological (HR and/or O_2 uptake) responses, the corresponding OG walking speed would need to be faster to elicit the desired response. This finding also questions the validity of extending the outcomes of TM-based exercise training studies to home-based training initiatives that primarily employ OG walking.

The increased walking speed and metabolic load observed during OG when compared with TM in the present study may be related to familiarity of OG walking. Marsh et al. (31) reported that older adults tend to walk at slower speeds on a TM, with an elevated perception of stress, when compared with OG walking. Age appears to be an important determinant of TM walking strategies, given that that small differences in walking pattern during TM and OG are within the normal stride-to-stride variation for younger (32), but not older individuals (11). Indeed, when Watt et al. (11) controlled walking speed for both TM and OG walking, older adults employed a significantly increased step rate and decreased stride length (and thus decreased stride time) during TM walking (11). While we did not examine walking kinematics, such differences in walking patterns among healthy older adults may explain the differences in walking economy in the present study: the O_2 cost per meter of TM walking (12.0 ± 3.0 $mL \cdot m^{-1}$) was significantly increased (i.e., less economical) when compared with OG walking (11.2 ± 2.5 $mL \cdot m^{-1}$). It would be tempting to use this finding and recommend less economical TM walking for the promotion of weight loss in older adults; however, the lower total

O_2 cost (i.e., metabolic load) of TM walking, despite the increased O_2 cost per distance traveled, may have negative implications for those using exercise training to assist in weight loss; for example, TM walking would require a longer total exercise duration to achieve a given caloric expenditure. The different and apparently "unnatural" walking pattern employed during TM walking, therefore, promotes the benefits of OG walking within the context of home-based and/or community-based exercise prescription for older women.

The present study demonstrated that the self-selected OG walking speed of older women was statistically related to their peak O_2 uptake. Our findings in older women support those of Cunningham et al. (33), who reported that self-selected OG walking speed of males aged 19–66 y was related to VO_2max. Moreover, our findings extend those reported by Spelman et al. (34), who covertly observed younger (~35 y) and mostly female participants during habitual walking and found that self-selected OG walking speed was significantly associated with VO_2max. These findings support that physiological functional capacity is a determinant of self-selected OG walking speed, although we did not observe a similar relationship for TM walking. This finding is initially peculiar, given that peak O_2 uptake was determined during TM walking to volitional fatigue; thus, it would be logical to extrapolate that self-selected speed during TM walking would relate to peak O_2 uptake in the same mode. Our finding is also at odds with an earlier study that reported preferred TM walking speed of older adults had a significant correlation with peak O_2 uptake (35). This incongruent finding is likely due to the different methods employed by Malatesta et al. (35) and the present study (i.e., our participants were able to freely modify the TM speed at any time during the 30-min walk, whereas participants in Malatesta et al. (35) walked at a fixed predetermined speed identified during familiarization). Our findings indicate that physiological functional capacity does not influence comfort nor confidence (e.g., RPE values) during submaximal walking on a motorized TM by older women, although self-selected OG walking speed is significantly determined by peak O_2 uptake.

The tendency for participants to increase their walking speed during the TM walking trials, compared to little or no change in the OG walking speed, is intriguing. While we stopped the participants walking at 30 min, it would now be important to determine if, given a longer walking time, the difference in walking speeds became negligible, or whether the difference would be still apparent following long-term use of a motorized TM. It may be that, with prolonged acclimation to TM walking, there would be less of an increase in self-selected walking speed across an exercise period.

A limitation of this work was the relatively small number of participants; study recruitment was limited by the previous exercise history. A second limitation were the cues given; specifically, participants may have been advised to exercise at an intensity that may benefit their health, but this walking speed may not have been the same as if they were not participating in the study. Finally, outcomes might have been different had OG walking been conducted in a neighborhood where ground conditions and inclines are less controlled.

In conclusion, we found that when older women are given the opportunity to perform 30 min of walking, they inherently choose a walking speed that approximates the optimal intensity for inducing the health-derived benefits of regular exercise training, which agrees with current exercise guidelines by major medical and health associations. The VT has a strong influence on the self-selected exercise intensity employed by older women, which is the upper limit of exercise that is known to have very low risk of adverse events. Moreover, self-selected walking speed during OG walking appears to provide an indirect and low-cost indication of the intensity associated with the VT independent from expensive and specialized equipment and therefore may serve useful when selecting walking speeds for exercise prescription. Given that access to specialized equipment and personnel represent significant barriers for exercise prescription, in addition to the associated cost which may often be prohibitive to older individuals, these findings reinforce the validity of clinician and clinical exercise physiologist directed, but unsupervised, exercise programs for achieving optimal health management for older women.

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REFERENCES

1. American College of Sports Medicine. American College of Sports Medicine Position Stand. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. Med Sci Sports Exerc. 1998;30(6):975–91.
2. Nelson ME, Rejeski WJ, Blair SN, Duncan PW, Judge JO, King AC, Macera CA, Castaneda-Sceppa C. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc. 2007;39(8):1435–45.
3. Riebe D, Ehrman JK, Liguori G, Magal M. ACSM's guidelines for exercise testing and prescription. 10 ed. Philadelphia, PA: Wolters Kluwer; 2018.
4. Strath SJ, Kaminsky LA, Ainsworth BE, Ekelund U, Freedson PS, Gary RA, Richardson CR, Smith DT, Swartz AM; American Heart Association Physical Activity Committee of the Council on Lifestyle and Cardiometabolic Health and Cardiovascular, Exercise, Cardiac Rehabilitation and Prevention Committee of the Council on Clinical Cardiology, and Council. Guide to the assessment of physical activity: clinical and research applications: a scientific statement from

the American Heart Association. Circulation. 2013;128(20):2259–79.

5. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, Nieman DC, Swain DP; American College of Sports Medicine. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc. 2011;43(7):1334–59.
6. Mann T, Lamberts RP, Lambert MI. Methods of prescribing relative exercise intensity: physiological and practical considerations. Sports Med. 2013;43(7):613–25.
7. Haykowsky M, McGavock J, Vonder Muhll I, Koller M, Mandic S, Welsh R, Taylor D. Effect of exercise training on peak aerobic power, left ventricular morphology, and muscle strength in healthy older women. J Gerontol A Biol Sci Med Sci. 2005;60(3):307–11.
8. Schnohr P, Scharling H, Jensen JS. Intensity versus duration of walking, impact on mortality: the Copenhagen City Heart Study. Eur J Cardiovasc Prev Rehabil. 2007;14(1):72–8.
9. Murtagh EM, Boreham CA, Murphy MH. Speed and exercise intensity of recreational walkers. Prev Med. 2002;35(4):397–400.
10. Parise C, Sternfeld B, Samuels S, Tager IB. Brisk walking speed in older adults who walk for exercise. J Am Geriatr Soc. 2004;52(3):411–6.
11. Watt JR, Franz JR, Jackson K, Dicharry J, Riley PO, Kerrigan DC. A three-dimensional kinematic and kinetic comparison of overground and treadmill walking in healthy elderly subjects. Clin Biomech. 2010;25(5):444–9.
12. Australian Bureau of Statistics. Australian health survey: physical activity, 2011–12. In: Canberra Australian Bureau of Statistics 2013.
13. Australian Institute of Health and Welfare. Australia’s health 2004. In: Canberra Australian Institute of Health and Welfare 2004.
14. Australian Bureau of Statistics. 2004–05 National health survey: summary of results. In: Canberra Australian Bureau of Statistics 2006.
15. Gass G, Gass E. Is exercise the “wonder drug” for older individuals? Eur Rev Aging Phys Activ. 2004;1:4–17.
16. Pratt M, Macera CA, Wang G. Higher direct medical costs associated with physical inactivity. Phys Sportsmed. 2000;28(10):63.
17. Dawes HN, Barker KL, Cockburn J, Roach N, Scott O, Wade D. Borg’s rating of perceived exertion scales: do the verbal anchors mean the same for different clinical groups? Arch Phys Med Rehabil. 2005;86(5):912–16.
18. Schneider DA, Phillips SE, Stoffolano S. The simplified V-slope method of detecting the gas exchange threshold. Med Sci Sports Exerc. 1993;25(10):1180–4.
19. Haralambous B, Osborne D, Fearn M, Black K, Nankervis J, Hill K. Participation in physical activity amongst older people. In: National Ageing Research Institute Department of Human Services Victoria, ed. Melbourne, 2003.
20. Baggish AL, Hale A, Weiner RB, Lewis GD, Systrom D, Wang F, Wang TJ, Chan SY. Dynamic regulation of circulating microRNA during acute exhaustive exercise and sustained aerobic exercise training. J Physiol. 2011;589(Pt 16):3983–94.
21. Keller P, El-Sheikh M. Children’s emotional security and sleep: longitudinal relations and directions of effects. J Child Psychol Psychiatry. 2011;52(1):64–71.
22. Lobelo F, Steinacker JM, Duperly J, Hutber A. Physical activity promotion in health care settings: the “exercise is medicine” global health initiative perspective. Schweiz Z Sportmed Sporttraumatol. 2014;62(2):42–5.
23. Gregg EW, Cauley JA, Stone K, Thompson TJ, Bauer DC, Cummings SR, Ensrud KE; Study of Osteoporotic Fractures Research Group. Relationship of changes in physical activity and mortality among older women. JAMA. 2003;289(18):2379–86.
24. Bethancourt HJ, Rosenberg DE, Beatty T, Arterburn DE. Barriers to and facilitators of physical activity program use among older adults. Clin Med Res. 2014;12(1–2):10–20.
25. Bird S, Radermacher H, Feldman S, Browning C, Thomas S. Factors influencing the physical activity levels of older people from culturally-diverse communities: an Australian experience. Ageing Soc. 2009;29(Special Issue 08):1275–94.
26. Crone-Grant DM, Smith RA. Exercise adherence: a qualitative perspective. J Sport Sci. 1998;16:75.
27. Petrella RJ, Koval JJ, Cunningham DA, Paterson DH. Can primary care doctors prescribe exercise to improve fitness? Am J Prev Med. 24(4):316–22.
28. Lind E, Joens-Matre RR, Ekkekakis P. What intensity of physical activity do previously sedentary middle-aged women select? Evidence of a coherent pattern from physiological, perceptual, and affective markers. Prev Med. 2005;40(4):407–19.
29. Thompson PD, Franklin BA, Balady GJ, Blair SN, Corrado D, Estes NA 3rd, Fulton JE, Gordon NF, Haskell WL, Link MS, Maron BJ, Mittleman MA, Pelliccia A, Wenger NK, Willich SN, Costa F; American Heart Association Council on Nutrition, Physical Activity, and Metabolism; American Heart Association Council on Clinical Cardiology; American College of Sports Medicine. Exercise and acute cardiovascular events placing the risks into perspective: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism and the Council on Clinical Cardiology. Circulation. 2007;115(17):2358–68.
30. Perri MG, Anton SD, Durning PE, Ketterson TU, Sydeman SJ, Berlant NE, Kanasky WF Jr, Newton RL Jr, Limacher MC, Martin AD. Adherence to exercise prescriptions: effects of prescribing moderate versus higher levels of intensity and frequency. Health Psychol. 2002;21(5):452–8.
31. Marsh AP, Katula JA, Pacchia CF, Johnson LC, Koury KL, Rejeski WJ. Effect of treadmill and overground walking on function and attitudes in older adults. Med Sci Sports Exerc. 2006;38(6):1157–64.
32. Riley PO, Paolini G, Della Croce U, Paylo KW, Kerrigan DC. A kinematic and kinetic comparison of overground and treadmill walking in healthy subjects. Gait Posture. 2007;26(1):17–24.
33. Cunningham DA, Rechnitzer PA, Pearce ME, Donner AP. Determinants of self-selected walking pace across ages 19 to 66. J Gerontol. 1982;37(5):560–4.
34. Spelman CC, Pate RR, Macera CA, Ward DS. Self-selected exercise intensity of habitual walkers. Med Sci Sports Exerc. 1993;25(10):1174–9.
35. Malatesta D, Simar D, Dauvilliers Y, Candau R, Ben Saad H, Préfaut C, Caillaud C. Aerobic determinants of the decline in preferred walking speed in healthy, active 65- and 80-year-olds. Pflugers Arch. 2004;447(6):915–21.