Journal of Physical Activity and Health, 2011, 8, 45-51

Determination of Step Rate Thresholds Corresponding to Physical Activity Intensity Classifications in Adults

Mark Abel, James Hannon, David Mullineaux, and Aaron Beighle

Background: Current recommendations call for adults to be physically active at moderate and/or vigorous intensities. Given the popularity of walking and running, the use of step rates may provide a practical and inexpensive means to evaluate ambulatory intensity. Thus, the purpose of this study was to identify step rate thresholds that correspond to various intensity classifications. ***Methods:*** Oxygen consumption was measured at rest and during 10 minute treadmill walking and running trials at 6 standardized speeds (54, 80, 107, 134, 161, and 188 m·min^{-1}) in 9 men and 10 women (28.8 ± 6.8 yrs). Two observers counted the participants' steps at each treadmill speed. Linear and nonlinear regression analyses were used to develop prediction equations to ascertain step rate thresholds at various intensities. ***Results:*** Nonlinear regression analysis of the metabolic cost versus step rates across all treadmill speeds yielded the highest R^2 values for men (R^2 = .91) and women (R^2 = .79). For men, the nonlinear analysis yielded 94 and 125 step·min^{-1} for moderate and vigorous intensities, respectively. For women, 99 and 135 step·min^{-1} corresponded with moderate and vigorous intensities, respectively. ***Conclusions:*** Promoting a step rate of 100 step·min^{-1} may serve as a practical public health recommendation to exercise at moderate intensity.

Keywords: exercise, pedometer, running, walking

Engaging in adequate amounts of physical activity is one key component to leading a healthy lifestyle. Approximately 69% of adults in the United States do not engage in sufficient amounts of physical activity.[1] The American College of Sports Medicine (ACSM) and the American Heart Association (AHA) released a revised set of physical activity guidelines for adults to obtain health benefits. These guidelines state, "To promote and maintain health, all healthy adults aged 18 to 65 years need moderate-intensity aerobic physical activity for a minimum of 30 minutes on 5 days each week or vigorous-intensity aerobic activity for a minimum of 20 minutes on 3 days each week."[2] In addition, the United States Department of Health and Human Services recommends that adults perform 150 minutes of moderate-intensity aerobic activity each week or 75 minutes of vigorous-intensity aerobic activity each week.[3] To use these guidelines, it is important that the public is able to effectively interpret the meaning of *moderate*- and *vigorous*-intensity physical activity.

There are numerous ways to objectively measure the intensity of physical activity, including the use of gas analyzers, heart rate telemetry, accelerometry, and global positioning system technology. Although these methods may be used independently or combined to provide estimates of physical activity intensity, they are relatively expensive and require training to use. In contrast, spring-levered (SL) pedometers are less expensive, less obtrusive, more user-friendly, and may be used as a motivational tool.[4] Traditionally, SL pedometers have been used to provide an estimate of overall physical activity volume by tracking daily step counts. Although estimates of physical activity volume are important because they coincide with current physical activity recommendations, measures of specific physical activity parameters (ie, intensity & duration) may provide more detailed and meaningful information regarding physical activity patterns for the general public, clinicians, and researchers. Recently, a SL pedometer (ie, Walk4Life Model: MVPa, Plainfield, IL) has been made available that can quantify the duration of ambulatory activity performed at moderate or vigorous intensities. This SL pedometer has a unique function that allows the user to set the pedometer's step rate (quantified in step·min^{-1}) to identify a given intensity threshold. That is, a step rate that identifies a moderate or vigorous ambulatory intensity can be set by the user. At any time, when the user's step rate is equal to or greater than the programmed step rate an internal timer is activated to accumulate the total time spent at or above the step rate threshold. This is a novel pedometer function that is easy to set and may provide important feedback to the user regarding their physical activity level and help the user to determine whether they are meeting current physical activity guidelines. Furthermore, even without a pedometer, the public may be able

Abel, Mullineaux, and Beighle are with the Dept of Kinesiology and Health Promotion, University of Kentucky, Lexington, KY. Hannon is with the Dept of Exercise and Sport Science, University of Utah, Salt Lake City, UT.

to use a step rate (ie, steps taken per minute) to determine whether their ambulatory pace is adequate to meet current physical activity recommendations for intensity. The individual simply needs to count the number of steps taken at any point while walking/running at a constant pace over level ground for a short period of time (eg, 6, 10, 15, 30 seconds), then multiply the step count by the number of time segments in 1 minute. For simplicity, we suggest using a 6-second sampling duration so the user only needs to add a 0 to the step count to calculate their step rate. For instance, if an individual took 12 steps in a 6-second period, then they are walking at a rate of 120 step·min^{-1} (12 steps × 10 6-second periods in 1 minute = 120 step·min^{-1}). Alternatively, individuals may choose to have another person time them for a given period of time while they count their own steps to quantify their step rate. This step count can be performed at any point during a workout to provide immediate feedback regarding ambulatory intensity.

Using step rates to define various intensity thresholds may allow the public to easily compare their physical activity level to current physical activity recommendations. Furthermore, pedometers with a step rate function may provide researchers and health practitioners with an alternative instrument to quantify time spent in moderate-to-vigorous physical activity. Although there is limited research on this topic, 2 studies have been conducted that have identified step rates that correspond to objectively defined intensity classifications.[5,6] These studies have indicated that walking at a pace of approximately 100 step·min^{-1} corresponds to moderate intensity and this heuristic may be used to promote a public health recommendation of accumulating 3000 steps in 30 minutes (100 step·min^{-1} × 30 min = 3000 steps) to meet current physical activity recommendations.[5,6] Although these studies present insightful findings, they may be methodologically limited by their use of an estimate of resting metabolic rate (ie, 3.5 ml·kg^{-1}·min^{-1}) to identify the step rate associated with a given metabolic equivalent (MET). Measuring (instead of estimating) resting metabolic rate will provide a more accurate assessment of each individual's 1 MET value, and thus may affect step rates that correspond to various MET-based thresholds (eg, 3 METs = moderate intensity). In addition, there is limited research using running as a mode to identify step rates that correspond to vigorous intensities. Therefore, the purpose of this study was to identify step rates in men and women that correspond to various intensity classifications using multiple walking and running treadmill speeds while measuring resting metabolic rate.

Methods

Participants

A convenience sample of 9 men and 10 women were recruited from a university population. To ensure participants could complete the treadmill protocol used in this study, only participants who had been running at least 3 d·wk^{-1} for a minimum of 30 minutes in duration, for at least 2 months before testing were enrolled. The participants' physical characteristics are presented in Table 1. The study procedures were approved by the University's Institutional Review Board and all participants provided written informed consent before participation in the study.

Body Composition Procedures

Height was measured to the nearest 0.1 cm without shoes using a wall mounted stadiometer. Waist circumference was measured at the narrowest part of the torso and hip circumference was measured at the maximal circumference of the hips or buttocks region.[7] All circumference measurements were measured in triplicate to the nearest 0.1 cm, with the average measurement used for analysis. Body composition was evaluated using whole body plethysmography (BOD POD Body Composition System, Life Measurement Instruments, Concord, CA). Specifically, the participant's body mass was measured while wearing a bathing suit or lycra clothing on an

Table 1 Participants' Characteristics (Mean ± SD)

	Men (n = 9)	Women (n = 10)	All subjects (N = 19)
Age (yr)	27.1 ± 3.1	30.3 ± 8.9	28.8 ± 6.8
Height (m)	1.82 ± 0.08	1.60 ± 0.09	1.71 ± 0.14
Mass (kg)	82.8 ± 12.0	55.5 ± 6.8	68.5 ± 16.8
BMI (kg·m^{-2})	24.8 ± 2.1	21.9 ± 4.4	23.2 ± 3.7
Waist cir. (cm)	83.5 ± 5.7	67.6 ± 6.3	75.2 ± 10.0
Hip cir. (cm)	100.9 ± 7.7	91.7 ± 6.7	96.1 ± 8.4
W/H ratio	0.83 ± 0.02	0.74 ± 0.03	0.78 ± 0.05
Fat (%)	15.4 ± 7.6	22.2 ± 7.0	19.0 ± 7.9
Resting VO_2 (ml·kg^{-1}·min^{-1})	3.3 ± 0.6	3.6 ± 0.7	3.5 ± 0.7

Abbreviations: BMI, body mass index; Waist cir., waist circumference; Hip cir., hip circumference; W/H ratio, waist circumference-to-hip circumference ratio.

electronic scale. A standard 2-point procedure was used to calibrate the pressure-volume relationship in the BOD POD chamber and thoracic gas volume was estimated by the BOD POD software.

Resting Metabolic Rate Procedures

Participants were asked to refrain from the use of any stimulants (ie, caffeine, tobacco, and medication) for 24 hours and to fast for at least 12 hours overnight, with the exception of water, before the 5:30–7:30 AM testing session. Resting metabolic rate was assessed using indirect calorimetry (TrueMax 2400, Parvo Medics Inc., Sandy, UT). A 3 L syringe was used to calibrate the flowmeter. The gas analyzer was calibrated with known concentrations of oxygen (16%) and carbon dioxide (4%). For familiarization purposes, the participant sat in a dimly lit room for 20 minutes while wearing a face mask that used 2-way nonrebreathing valves (Hans Rudolph Inc., Kansas City, MO). Next, the hose from the metabolic cart was connected to the face mask and expiratory gases were collected for 22 minutes. The first 2 minutes of expiratory gas data were discarded to allow for the expiratory gases to reach the metabolic cart's mixing chamber. The remaining 20 minutes of expiratory gas data were averaged and used to calculate resting oxygen uptake ($ml \cdot kg^{-1} \cdot min^{-1}$). To calculate METs during the treadmill walking and running trials, the participant's gross oxygen uptake ($ml \cdot kg^{-1} \cdot min^{-1}$) was divided by their resting oxygen uptake. The MET values of ≤2.99 (light), 3.00–5.99 (moderate), 6.00–8.99 (vigorous), and ≥9.0 (very hard) were used to identify the 4 physical activity intensity categories.

Treadmill Procedures

Before the treadmill walking and running trials, the metabolic system was recalibrated. The treadmill's (Quinton Instruments Company, Seattle, Washington) speed and grade were calibrated before and during the study by following standard procedures.[8] The participants were instructed how to properly straddle the treadmill belt while it was moving and how to safely step on and off of the moving treadmill belt while leading with the right foot. Each participant was then fitted with a mouthpiece consisting of a 2-way nonrebreathing valve (Hans Rudolph Inc., Kansas City, MO) and a nose clip to collect expiratory gases. The first 3 minutes of expiratory gas data from each 10 minute treadmill trial were discarded to ensure oxygen uptake reached a steady state level. The remaining 7 minutes of oxygen uptake data were averaged to calculate the volume of oxygen consumed (VO_2) for a given treadmill speed.

Participants completed a series of 3 10-minute treadmill walking trials at speeds of 54, 80, and 107 $m \cdot min^{-1}$ and 3 10-minute treadmill running trials at speeds of 134, 161, and 188 $m \cdot min^{-1}$ with 0% grade in progressive order. A 2-minute rest period was provided between each treadmill trial where participants straddled the treadmill belt and were allowed to breathe without the mouth piece and drink water.

Two investigators used hand tally counters to ascertain the observed number of steps taken during each treadmill trial. Each right step taken by the participant was counted by the observers and the total hand tally count from each trail was multiplied by 2. A video recorder was used to film the steps taken by each participant during the treadmill trials to serve as a back-up in case discrepancies occurred between observers' step counts. The video was not needed because a reliability analysis of the observers' step counts resulted in a Cronbach's alpha of 1.0 for all treadmill walking and running trials.

Statistical Analysis

Linear and nonlinear regression analyses were both used to identify the most appropriate type of regression analysis to assess the relationship between the participants' step rate and metabolic cost (ie, METs) in men and women. In addition, separate mixed ANOVA were used to assess the between subjects effect of sex (men vs. women) and the within subjects effect of speed (54, 80, 107, 134, 161, 188 $m \cdot min^{-1}$) for the 4 dependent measures of step rate, stride length, VO_2, and METs. Level of significance was set at $P < .01$ for all analyses. Pearson product moment correlations were performed to assess the relationship between the participants' height versus step rate and stride length. SPSS version 16.0 was used for all statistical analyses.

Results

Linear and nonlinear correlations between MET values and step rates are displayed in Figures 1 and 2, respectively. The linear correlation for men and women yielded R^2 values of 0.71 and 0.85, respectively. The nonlinear correlation for men and women yielded R^2 values of 0.79 and 0.91, respectively. Specific step rate thresholds were identified for various physical activity intensity classifications using linear and nonlinear regression equations and are displayed in Table 2.

There were significant main effects of treadmill speed on step rate, stride length, VO_2, and MET values (Table 3). Such that, each increase in treadmill speed produced a significant increase in each of these outcome measures, except stride length between 107 and 134 $m \cdot min^{-1}$ (men: $P = .244$; women: $P = .988$). There was a significant effect of sex on step rate, stride length, and VO_2 (Table 3). Such that, at select treadmill speeds men had a lower step rate, a longer stride length, and a lower relative VO_2 compared with women. There was no effect of sex on MET values.

Bivariate correlations between the participants' height and step rate at each treadmill speed yielded significant ($P < .05$) inverse correlation coefficients ranging from –0.537 to –0.769. In addition, the participants' height was positively correlated to stride length (r-value range: 0.545–0.744, $P < .05$) at each treadmill speed. That is, at a given treadmill speed, taller participants used slower step rates and longer stride lengths compared with shorter participants.

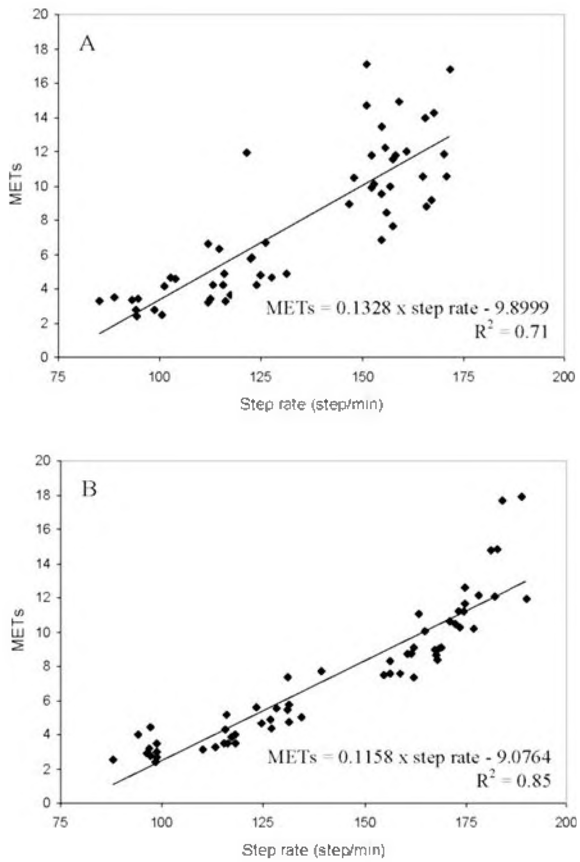

Figure 1 — Linear relationship between step rate and METs for A) male and B) female participants during treadmill walking and running.

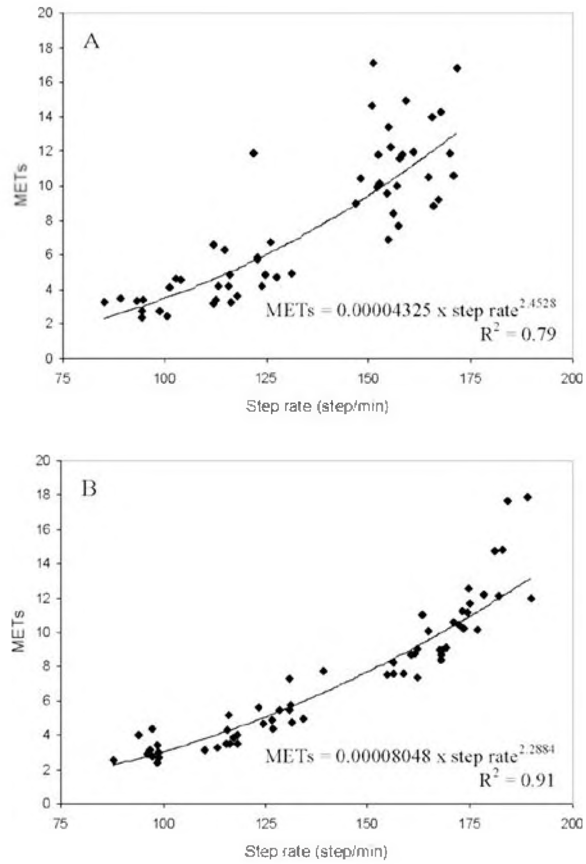

Figure 2 — Nonlinear relationship between step rate and METs for A) male and B) female participants during treadmill walking and running.

Table 2 Step Rate (step·min^{-1}) Equivalents That Correspond to Various Physical Activity Intensity Classifications From the Present Study (Abel) Using Linear and Nonlinear Analyses, and From Tudor-Locke et al[5] and Marshall et al[6]

	Males				Females			
	Abel	Abel	Tudor	Marshall	Abel	Abel	Tudor	Marshall
Intensity classification	Linear	Nonlinear	Linear	*	Linear	Nonlinear	Linear	*
Walking								
Light (≤2.99 METs)	<97	<94	<96	<92/101/102	<104	<99	<107	<91/111/115
Moderate (3–5.99 METs)	97–119	94–124	96–124	92/101/102	104–129	99–134	107–135	91/111/115*
Running								
Vigorous (6.0–8.99 METs)	120–142	125–147	125–153	ND	130–156	135–160	136–162	ND
Very hard (≥9.0 METs)	>142	>147	>153	ND	>156	>160	>162	ND

Abbreviations: Tudor. Tudor-Locke et al;[5] Marshall. Marshall et al;[6] ND. no data provided.

* Multiple regression analysis/mixed-model analysis/receiver operating characteristic (ROC) curve analysis for minimum step rates for moderate intensity (3 METs).

Table 3 Step Rate, Stride Length, VO_2, and METs (Mean ± SD) in 9 Men and 10 Women for Different Treadmill Walking and Running Speeds

	Treadmill speed					
	Walking			Running		
Dependent variables	54 m·min⁻¹	80 m·min⁻¹	107 m·min⁻¹	134 m·min⁻¹	161 m·min⁻¹	188 m·min⁻¹
Step rate (step·min⁻¹)						
Males	94.6 ± 5.2[a]	111.5 ± 5.3[a]	122.8 ± 6.1[a,c]	151.4 ± 12.6[a]	158.4 ± 6.5[a,c]	162.0 ± 7.7[a,c]
Females	96.4 ± 3.4[a]	116.4 ± 3.4[a]	130.5 ± 4.2[a]	163.4 ± 7.5[a]	171.5 ± 7.3[a]	177.0 ± 9.3[a]
Stride length (m·step⁻¹)						
Males	0.57 ± 0.03[a]	0.72 ± 0.04[a]	0.87 ± 0.04[b,c]	0.89 ± 0.09[b]	1.02 ± 0.04[a,c]	1.16 ± 0.05[a,c]
Females	0.56 ± 0.02[a]	0.69 ± 0.02[a]	0.82 ± 0.03[b]	0.82 ± 0.04[b]	0.94 ± 0.04[a]	1.06 ± 0.06[a]
VO_2 (ml·kg⁻¹·min⁻¹)						
Males	10.0 ± 0.6[a]	12.9 ± 0.7[a]	17.8 ± 0.6[a,c]	30.7 ± 1.8[a]	36.7 ± 2.1[a]	42.8 ± 2.7[a]
Females	11.0 ± 1.1[a]	14.0 ± 1.2[a]	19.4 ± 1.3[a]	31.0 ± 2.7[a]	36.8 ± 2.2[a]	44.0 ± 2.3[a]
METs						
Males	3.1 ± 0.6[a]	4.0 ± 0.6[a]	5.5 ± 0.9[a]	9.6 ± 1.7[a]	11.4 ± 2.1[a]	13.4 ± 2.6[a]
Females	3.1 ± 0.6[a]	4.0 ± 0.8[a]	5.5 ± 1.1[a]	8.8 ± 1.8[a]	10.5 ± 2.3[a]	12.6 ± 2.8[a]

[a] Significant effect of speed between each successive increase in speed ($P < .01$), except for "[b]".

[c] Significant difference between males and females ($P < .01$).

Discussion

The purpose of this study was to identify step rates in men and women that correspond to objectively defined physical activity intensities. The main findings indicate that to achieve moderate intensity men and women should walk at a pace of at least 100 step·min⁻¹ (men ≥ 94 step·min⁻¹; women ≥ 99 step·min⁻¹). Thus, "100 step·min⁻¹" may provide individuals with an objective, yet practical guideline to determine whether they are meeting the intensity requirements of current physical activity recommendations.[2] For instance, a man or woman can determine if he or she is meeting the required intensity by simply counting the number of steps taken per 6-second time period. If the step count per 6-second time period is 10 or greater, that would indicate that the individual is walking at a pace of approximately 100 step·min⁻¹ or more, which would be considered at least moderate intensity. In addition, individuals may use these step rate guidelines (Table 2) to set pedometers that have a step rate function to the appropriate level to quantify the amount of time spent in certain intensity classifications during a single exercise bout or accumulated throughout the day. Finally, these step rate-based pedometers may provide researchers and health practitioners with a relatively low cost, objective instrument that generates more meaningful data regarding the dose-response relationship of ambulatory parameters (ie, intensity, duration, & frequency) for various health outcomes.

To date, 2 studies have used step rates to estimate ambulatory intensity. We present their findings and briefly compare the methodological characteristics of these studies to those of the current investigation. Table 2 illustrates a summary of their findings. First, Tudor-Locke et al[5] conducted an investigation to ascertain step count guidelines for classifying walking intensity in men and women. Their findings indicated that moderate intensity corresponded with men walking at a pace ≥ 96 step·min⁻¹ and women walking at a pace ≥ 107 step·min⁻¹. Vigorous intensities corresponded to men ambulating at a pace ≥ 125 step·min⁻¹ and women ≥ 136 step·min⁻¹. The comparable findings of the current study with Tudor-Locke et al[5] are encouraging despite several methodological differences. For instance, the current study used a greater number and range of walking and running speeds, used 2 observers to assess step counts (Tudor-Locke et al[5] used pedometers), and performed an actual measurement of resting metabolic rate to calculate MET values. Both investigations used a linear regression model to assess the metabolic cost (ie, MET values) versus step rate relationship. Tudor-Locke et al[5] reported R^2 values of 0.80 for men and 0.83 for women. The current study yielded linear regression R^2 values of 0.71 for men and 0.85 for women. However, it was noted that using a nonlinear regression analysis improved the R^2 values in the current study to 0.79 for men and 0.91 for women. Thus, using a nonlinear regression model, the step rate accounted for an additional 8% of the variance in metabolic cost among men and 6% of the variance in metabolic cost among women. Research has indicated that there are differences in the metabolic economy of walking versus running.[9] These economical differences are primarily due to changes in muscle contraction length and the rate of muscle contraction required to produce changes in stride length and stride rate at different ambulatory speeds.[10] Specifically, the metabolic cost per step is greater for running compared with walking. Our data indicate that the mean metabolic cost (VO_2) per step was approximately 32% higher for running than for walking (walking: 0.15 ml·kg^{-1}·step^{-1}; running: 0.22 ml·kg^{-1}·step^{-1}). Thus, a nonlinear model with a greater than 1 power exponent supports the greater metabolic cost per step required to propel the body's mass forward at running speeds. Therefore, a nonlinear model may be more appropriate to assess the different relationships of metabolic cost versus step rate within a single set of data representing walking and running activity. One additional observation to make regarding the 2 statistical models used in this study is that the range of step rate values for the nonlinear model at moderate intensities and between the light-to-very hard intensity classifications tend to be slightly larger compared with the linear model. These discrepancies may be due to the positive curvilinear nature of the nonlinear model. That is, due to the curvilinear slope of the trendline, lesser values will be yielded at lower intensities and greater values will be yielded at higher intensities. In general, despite the discrepancies between these statistical models, the nonlinear model only deviated from the linear model by 5 step·min^{-1} or less (Table 2). It is likely that this relatively small difference should not have a large impact on the practical implications of determining a consensus step rate recommendation for the public.

Marshall et al[6] conducted a study to estimate step rate thresholds that corresponded to walking at a moderate intensity using 3 different statistical analyses. Depending on the statistical model used, their findings indicated that moderate intensity (ie, 3 METs) was associated with walking at a minimum step rate of 92 to 102 step·min^{-1} for men, and walking at a minimum step rate of 91 to 115 step·min^{-1} for women.[6] In general, these findings support the conclusions of the current study as our minimum threshold, moderate intensity step rates (ie, men: 94 step·min^{-1}; women: 99 step·min^{-1}) corresponded fairly closely with those reported by Marshall et al.[6] Again, the similar findings of these studies are encouraging given the differences between the studies' sample characteristics and methodologies. For instance, Marshall et al[6] used a sample of normal weight, overweight, and obese Latino adults. The current study used a sample of normal weight, recreationally trained, Caucasian adults. In addition, the current study measured resting metabolic rate, included walking and running treadmill speeds, and used linear and nonlinear regression analyses. Whereas Marshall et al[6] estimated resting metabolic rate (equivalent to 3.5 ml·kg^{-1}·min^{-1}), used walking treadmill speeds only, and used multiple regression, mixed modeling, and receiver operating characteristic (ROC) curve statistical analyses. Despite the differences between the current study, Tudor-Locke et al.,[5] and Marshall et al.,[6] their similar findings may indicate that one step rate threshold, 100 step·min^{-1}, may provide a consensus for a practical physical activity recommendation for the public.This study provided step rate thresholds that equate to various intensity classifications. However, it is important to acknowledge that factors, such as leg-length, can affect and alter these guidelines for individuals who have longer or shorter legs than the participants in this study. For instance, individuals with a longer leg length may have a longer stride length and lesser step rate when walking at the same absolute speed as an individual with a shorter leg length. The opposite would be true for an individual with a shorter leg-length. Differences in leg-length may have accounted for the gender differences in the mean step rate found at some walking and running speeds in the current study (Table 3). In addition, these step rate guidelines may not be appropriate for individuals who have a lower (eg, youth) or higher (eg, obese individuals) metabolic efficiency compared with the participants in this study. Thus, future research should be conducted to ascertain step rate guidelines for these groups of individuals or to develop a feasible protocol for individuals to ascertain an *individualized* step rate that corresponds to various intensity classifications. To that end, it is important to consider that step rates are a measure of *absolute* intensity, but not *relative* intensity. Consider the following example. If a trained person and an untrained person walked at the same step rate (ie, similar absolute intensity), the untrained person would be working at a greater relative intensity (eg, higher percentage of maximal oxygen uptake). Thus, the step rate recommendations found herein may be most applicable to recreationally trained individuals. However, these recommendations tend to be fairly robust for individuals of various fitness levels; as the minimum moderate intensity step rate thresholds identified in obese individuals by Marshall et al[6] are similar to those found in the current study.

In addition, there are several limitations of this study. For instance, this study used young, recreationally trained participants. Thus, findings from this study may not generalize to older, lesser-trained, and diseased populations. In addition, due to the rigorous methodological procedures used in this study (eg, measurement of resting metabolic rate and 60-minute treadmill bouts performed while in a fasted state), a small convenience sample was employed. Thus, no cross validation was performed on the prediction equations in this study. Finally, the results from this study provide support for similar findings reported by Tudor-Locke et al[5] and Marshall et al.[6] However, given the methodological strengths of the current study, these findings, combined with those in the literature offer a strong body of evidence that will support the development of a consensus step rate recommendation for the public. Future research should focus on the effect of leg-length, age, body composition, and training status to further refine step rate recommendations.

In conclusion, the recent update of ACSM/AHA physical activity guidelines[2] provide researchers, health practitioners, and the public with explicit recommendations regarding the frequency, duration, and intensity for which healthy adults should perform physical activity. To effectively apply these guidelines, individuals need an objective, yet practical way of assessing the intensity of physical activity. One strategy may be to use step rate guidelines. The findings from this study indicate that men and women should walk at a pace equal to or greater than 100 step·min^{-1} to engage in moderate intensity physical activity.

Acknowledgments

The authors wish to thank Katie Sell, Ph.D., Tia Lillie, Ph.D., Geri Conlin, David Anderson, and Kelly Bird for their assistance in data collection.

References

1. Unites States Department of Health and Human Services. *Health, United States, 2007. With chartbook on trends in the health of Americans*. Hyattsville, MD: National Center for Health Statistics; 2007.
2. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc*. 2007;39(8):1423–1434.
3. Physical Activity Guidelines Advisory Committee. *Physical Activity Guidelines Advisory Committee Report, 2008*. Washington, DC: United States Department of Health and Human Services; 2008.
4. Haines, DJ, Davis, L, Rancour, P, Robinson, M, Neel-Wilson, T, Wagner, S. A pilot intervention to promote walking and wellness and to improve the health of college faculty and staff. *J Am Coll Health*. 2007;55(4):219–225.
5. Tudor-Locke C, Sisson SB, Collova T, Lee SM, Swan PD. Pedometer-determined step count guidelines for classifying walking intensity in a young ostensibly healthy population. *Can J Appl Physiol*. 2005;30(6):666–676.
6. Marshall SJ, Levy SS, Tudor-Locke CE, et al. Translating physical activity recommendations into a pedometer-based step goal. *Am J Prev Med*. 2009;36(5):410–415.
7. American College of Sports Medicine. Health-related physical fitness testing and interpretation. In: Whaley M, ed. *ACSM's guidelines for exercise testing and prescription*. 7th ed. Philadelphia: Lippincott, Williams and Wilkins; 2006.
8. Howley ET, Franks DB. *Health fitness instructor's handbook*. 2nd ed. Champaign, IL: Human Kinetics; 1992.
9. Walker JL, Murray TD, Jackson AS, Morrow JR, Michaud-title TJ. The energy cost of horizontal walking and running in adolescents. *Med Sci Sports Exerc*. 1999;31(2):311–322.
10. Kram R, Taylor CR. Energetics of running: a new perspective. *Nature*. 1990;346(6281):265–267.