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Original research

Evaluation of inactive adults' ability to maintain a moderate-intensity walking pace

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ABSTRACT

Objectives: To determine self-selected brisk walking pace in currently inactive adults and investigate the efficacy of rhythmic auditory stimuli to regulate moderate intensity walking.
Design: A single-sample controlled laboratory design.
Methods: Currently inactive adults ($N = 25$; 76% female; age = 34 ± 13 yr) completed a moderate intensity treadmill walking trial, during which cadence and steady-state O_2 were measured. Participants then completed a 10-min self-paced "brisk" walk followed by a 10-min moderate-paced walk, prompted by a clip-on metronome matched to the treadmill cadence. Data were analyzed using RM *t*-test, Cohen's *d*, Bland–Altman plot, and one-way RM ANOVA.
Results: Mean energy expenditure and cadence during the treadmill trial were 3.88 ± 0.53 METs and 114 ± 8 steps min^{-1}. During self-paced brisk walking cadence was 124 ± 8 steps min^{-1}. Cadence during metronome-paced walking was slower for all participants (114 ± 8 steps min^{-1}; $p < 0.05$, $d = 1.23$). From the Bland–Altman plots, 23 participants walked within ±3 steps min^{-1} of the metronome cadence, and the other 2 participants were within ±10 steps min^{-1}. There were no significant differences ($p > 0.05$) among the minute-by-minute cadences across the 10 min of either condition.
Conclusions: Energy expenditure during 2.7 mph treadmill walking was higher than 3 METs. Inactive adults walk at a higher cadence during "brisk" walking, compared to walking at a metronome-guided moderate pace. While the natural walking pace of inactive adults was at an intensity known to produce health benefits, and was maintained for 10 min, the use of rhythmic auditory feedback is an effective method for regulating walking at a prescribed intensity in inactive adults.

1. Introduction

Walking has been described as "the nearest activity to perfect exercise",[1] as it is convenient, inexpensive, safe, and one of the most commonly reported modes of physical activity. Researchers have identified the key ingredients of successful interventions to increase walking, primarily targeting specific groups and individually tailoring.[2] However most interventions and guidelines incorporate only total volume of walking (e.g., in daily steps).[3] Although some interventions that have successfully increased walking volume have resulted in health benefits such as a reduction in blood pressure,[4] in other studies an increase in walking volume has not resulted in changes in health outcomes.[5] Current physical activity guidelines emphasize the moderate intensity threshold, and recognize the additional health benefits of higher intensities.[6,7] However, walking interventions typically focus on walking volume and rarely monitor or manipulate intensity other than via basic instructions such as to walk "briskly". Although there is some evidence that habitually active adults typically walk at a moderate intensity,[8,9] other studies have shown greater variability in brisk walking intensity in adults who report walking briskly for exercise.[10] To our knowledge, there is no evidence of brisk walking intensity in inactive adults.

Several recent controlled studies have demonstrated the utility of walking cadence (step rate) as a useful indicator of walking intensity during treadmill walking and overground walking.[11] Generally, a walking cadence of 100 steps min^{-1} has been shown to equate to 3 METs in adults,[11] but additional evidence suggests that moderate cadence varies with leg length or height.[12,13] Individually tailored cadences, taking into account height or leg length, therefore increases accuracy when prescribing walking for health. Additionally, studies with clinical populations have demonstrated

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the effectiveness of rhythmic auditory cues (e.g., a metronome or music with a discernible tempo) in gait rehabilitation,[14] but little evidence exists on the use of rhythmic auditory cues for manipulating walking intensity (via cadence) for the purposes of meeting public health physical activity guidelines. Particularly for adults who are unaccustomed to walking regularly at a moderate intensity, an entrainment effect may be possible using rhythmic auditory stimuli.

Besides moderate intensity, walking should be maintained for bouts of at least 10 min in order to optimize the potential for health benefits.[6] Maintaining continuous bouts of walking above 3 METs may be more difficult for inactive individuals, due to lower fitness, lower motivation, or lack of experience walking at moderate intensity. Consequently, an examination of self-paced walking intensity in inactive adults is warranted, as well as methods to regulate walking intensity in this population.

The purpose of the current study was to investigate walking cadence and intensity parameters in currently inactive adults, and test the efficacy of a rhythmic auditory stimulus to regulate walking intensity in this population. This was achieved via the following steps: (a) use of a moderate treadmill walking speed of 2.7 mph (72.42 m min^{-1}) to individually prescribe a moderate-intensity walking cadence; (b) determination of self-selected "brisk" overground walking speed and cadence, and whether this cadence can be maintained for 10 min; and (c) determination of inactive adults' ability to match an individualized cadence prescription via an external rhythmic auditory cue (metronome), and whether this also can be maintained for 10 min.

2. Methods

The design was a single-sample controlled laboratory study, in which participants were asked to participate in three walking conditions, while data were collected on oxygen consumption (treadmill condition only), heart rate, cadence, and perceived exertion.

Participants were recruited via a flyer that was distributed on the university campuses of the co-principal investigators (DR and MK). Prior to participation, volunteers were sent (a) an information sheet describing the study, (b) a Physical Activity Readiness Questionnaire (PAR-Q),[15] and (c) a brief single item physical activity survey (PA5). The PA5 has been shown to have high test–retest reliability and was validated against diary-reported MET-mins of physical activity and a variety of health-related fitness outcomes.[16] Inclusion criteria were (a) aged between 18 and 64 yr, (b) no potential risk of participation (as indicated by responses to the PAR-Q), and (c) currently inactive (not meeting physical activity recommendations, as indicated by a score of 1–3 on the PA5). All procedures were approved by the Institutional Review Board of both institutions, all participants completed an informed consent form prior to being tested, and the research was conducted in compliance with the principles of the Declaration of Helsinki.

Currently inactive adults ($N = 25$; 76% female; age = 34 ± 13 yr; height = 1.65 ± 0.10 m; weight = 77.55 ± 21.52 kg; BMI = 28.58 ± 7.48 kg m^{-2}) were tested at two institutions, in order to facilitate data collection more quickly. All procedures were replicated at both institutions, with only minor differences in equipment. Similar research has been completed in a multiple-site study previously, without any bias introduced by testing at separate sites.

Prior to the treadmill test, participants were provided a warm-up and familiarization trial of at least 3 min. Speed was gradually increased over 3 min until it reached 2.7 mph (72.42 m min^{-1}) in the third minute, after which they were given the opportunity to continue practicing and asked to indicate when they wished to stop. They were then fitted with a gas collection mask or mouthpiece and noseclip, NL-1000 pedometer (New Lifestyles, Lee's Summit, MO), GT1M accelerometer (Actigraph, LLC, Pensacola FL), and a Polar heart rate monitor (Polar Electro Oy, Kempele, Finland). The pedometer and accelerometer were worn for validation purposes and as a cross-check of cadence measures in the study. Participants were shown how to step onto a moving treadmill by standing astride the treadmill, holding onto the handrails and then stepping onto the belt following a countdown. They were given the opportunity to practice this until they felt confident. They were allowed to place their hands on the handrails for balance initially, but asked to remove them as soon as they were able. For the testing trial, they stood astride the treadmill while the speed was increased to 2.7 mph (72.42 m min^{-1}), which was confirmed by tachometer. When the participant indicated he/she was ready to start, the tester provided a verbal countdown ("5, 4, 3, 2, 1, walk") at which point the participant stepped onto the treadmill and began walking at 2.7 mph. This speed was selected based on American College of Sports Medicine metabolic equations,[17] to ensure that participants were at, or slightly above, an intensity of 3 METs. The trial lasted for at least 3 min, in order for heart rate and oxygen consumption to reach steady state. The trial ended if steady-state heart rate (two consecutive minutes within 5 beats min^{-1}) was achieved in the third minute.[17] If heart rate was not at steady state, an additional minute to 2 min were completed. During the third minute of the trial, steps were hand-counted using a tally counter, and this cadence was used for the metronome-guided trial. Also in each minute of the trial, the participant was asked to rate how hard they were walking, using the Rating of Perceived Exertion (RPE).[18] Pedometer steps were recorded at the end of the trial, after which the gas collection mask was removed. O_2 was measured using a Cosmed K4b^2 (Cosmed, Rome, Italy) portable analyzer at one site ($n = 8$), and an AEI Moxus metabolic cart and Ametek analysers (AEI Technologies, Naperville IL, USA) at the other site ($n = 17$).

Participants were then asked to walk around an indoor elliptical route, using a self-selected pace that was representative of what they considered to be a "brisk" pace. The route was marked with cones, and participants were given a brief practice walk, after which they walked continuously around the track for at least 10 min. At the 10-min point, the participant was asked to keep walking to the start/finish line. Cadence was initially hand-counted every other minute using a tally counter, but after piloting with 16 participants, we determined that hand-counted steps agreed with steps recorded via the Actigraph, and so the Actigraph was used as the criterion measure for step counts for the whole sample. Heart rate was recorded in 1-min epochs, and NL-1000 pedometer steps, number of laps, and time were recorded immediately following completion of the trial.

Participants subsequently completed a similar trial to the self-selected "brisk" trial, again for at least 10 min. The same protocol was followed, except that the participant was asked to walk at the same cadence as they walked during the 2.7 mph treadmill trial. This was guided using a clip-on metronome set to the hand-counted cadence recorded from the treadmill trial. Prior to the trial, participants were given practice walking in time with the metronome, and were provided voice prompts ("left, right", etc.) if their cadence did not match during the practice. During the testing trial, no verbal prompts were provided.

The order of the overground trials was not counterbalanced, in order to prevent contamination of the self-selected brisk trial by prior knowledge of what the researchers considered to be a moderate pace (i.e., via the metronome setting). Data were analyzed using single-sample t-tests, repeated measures t-tests, Cohen's d,[19] Bland–Altman plots,[20] and one-way repeated measures analyses of variance (ANOVA). Cohen's d is an indicator of effect size or clinical meaningfulness of an effect. Cohen provided interpretation