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Continuous walking and time- and intensity-matched interval walking: cardiometabolic demand and post-exercise enjoyment in insufficiently active, healthy adults

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ABSTRACT

We compared cardiometabolic demand and post-exercise enjoyment between continuous walking (CW) and time- and intensity-matched interval walking (IW) in insufficiently active adults. Sixteen individuals (13 females and three males, age 25.3 ± 11.1 years) completed one CW and one IW session lasting 30 min in a randomised counterbalanced design. For CW, participants walked at a mean intensity of 65-70% predicted maximum heart rate (HR_{max}). For IW, participants alternated between 3 min at 80% HR_{max} and 2 min at 50% HR_{max}. Expired gas was measured throughout each protocol. Participants rated post-exercise enjoyment following each protocol. Mean HR and $\dot{V}O_2$ showed small positive differences in IW vs. CW (2, 95%CL 0, 4 beat.min^{-1}; d = 0.23, 95%CL 0.06, 0.41 and 1.4, 95%CL 1.2 ml.kg^{-1}.min^{-1}, d = 0.36, 95%CL 0.05, 0.65, respectively). There was a medium positive difference in overall kcal expenditure in IW vs. CW (25, 95%CL 7 kcal, d = 0.58, 95%CL 0.33, 0.82). Post-exercise enjoyment was moderately greater following IW vs. CW (9.1, 95%CL 1.4, 16.8 AU, d = 0.62, 95%CL 0.06, 0.90), with 75% of participants reporting IW as more enjoyable. Interval walking elicits meaningfully greater energy expenditure and is more enjoyable than CW in insufficiently active, healthy adults.

Keywords: energy expenditure; affective responses; health; physical activity

INTRODUCTION

A common way of achieving health-enhancing physical activity (PA) is via structured exercise.[1] In recent years, high-intensity interval exercise (HIIE) has emerged as a popular exercise method. High-intensity interval exercise involves repeated bouts of intense or all-out activity interspersed with recovery periods. Evidence suggests that HIIE can elicit similar or greater health and fitness benefits than moderate-intensity continuous-exercise (MICE) within a given timeframe.[2] This evidence has led some researchers to suggest HIIE may be an effective tool for insufficiently active individuals.[3]

There is some evidence that the affective judgements (which includes the construct of enjoyment) of a PA experience such as an exercise session are associated with future exercise behaviour [4 5]. As adherence to an exercise intervention is a key determinant of its potential efficacy, measures of enjoyment should be factored into the evaluation of proposed interventions. A criticism of HIIE as a public health tool is that due to its high-intensity nature a large proportion of the general population are unlikely to find it enjoyable and therefore are unlikely to adhere to it [3 6]. However, review-level evidence indicates that in the majority of publications comparing HIIE and continuous exercise, enjoyment following HIIE was similar or greater than following continuous exercise [7 8].

Of the 18 publications reviewed by Stork, et al. [7] that compared post-exercise enjoyment of interval exercise and continuous exercise, 10 used participants who were a combination of sedentary, insufficiently active, presenting with pre-existing health conditions, overweight, or obese. Therefore, the enjoyment data on HIIE does not solely relate to healthy, physically active individuals. Nevertheless, there is notable heterogeneity in post-HIIE enjoyment responses [7 8]. This heterogeneity is likely rooted in HIIE protocol differences and individual differences. The number and duration of work bouts in a HIIE protocol, and overall protocol intensity, influence perceptions of HIIE [9-11]. Individual differences in aerobic fitness and self-reported tolerance of exercise intensity also influence perceptions of and intentions to repeat HIIE [9 12]. Taken together, this data suggests that HIIE may be worthy of further consideration as a tool for increasing general population PA. However, it is important that future work focuses on exploring alternative methods and modes of HIIE, as the available evidence clearly shows that a given HIIE intervention does not suit everyone.

Walking is an accessible activity with clear potential to improve public health [13]. Despite ease of access to this activity, prevalence statistics suggest that a large proportion of people are not engaging in sufficient PA or exercise to improve health [1]. As walking is of a lower intensity than other forms of activity lack of engagement may be less related to concerns about intensity and more related to perceptions regarding lack of time and enjoyment [14]. The available evidence suggests that HIIE is as enjoyable or more so than MICE [7], perhaps due to the constantly changing stimulus [15]. Therefore, an interval walking (IW) protocol may represent an accessible and enjoyable form of activity.

Currently, there are no data specifically detailing the acute cardiometabolic response to time- and intensity-matched IW compared with CW, nor on people's comparative enjoyment of these modes of activity. The time matching element is important in terms of assessing possible differences in health gains for the same time spent exercising, in contrast to much HIIE literature that considers the time-efficiency of interval based activity. Characterising the acute cardiometabolic response to IW would facilitate its appropriate prescription for attainment of specific goals (e.g. increased aerobic fitness, body composition changes). Quantifying enjoyment of IW is important due to the potential association between enjoyment of exercise and adherence to that exercise [4].

This study compared cardiometabolic and enjoyment responses between a single session of IW and CW in insufficiently active, healthy adults. We hypothesised that IW would elicit meaningfully greater energy expenditure than CW, and that participants would report IW to be meaningfully more enjoyable than CW.

METHODS

Participants

Sixteen adults (13 females and three males, mean age 25.3 ± 11.1 years, height 168 ± 9 cm, body mass 68.6 ± 13.4 kg, body mass index 24.4 ± 5.7, range 18.3 – 35.7) were recruited. Inclusion criteria were: safe to participate in exercise (determined via a physical activity readiness questionnaire), healthy with no known illness or other condition that could influence physiological responses to exercise (determined via a pre-study medical screening questionnaire), insufficiently active (defined as the participant self-reporting that they did not meet the current UK weekly PA guidelines [1] on average for the preceding six months), and unfamiliar with HIIE participation. Participants were recruited via advertisements in the Institution at which the research was conducted, and local businesses. As this was the first study to compare metabolic responses to CW and IW, we recruited healthy individuals free from known metabolic complications such as diabetes that could influence substrate use and perception of exercise difficulty [16 17]. This approach allowed us to generate a baseline metabolic response to CW and IW while minimising the potential influence of confounding factors. The study received ethical approval from a University of Edinburgh, Moray House School of Education ethics sub-committee.

Experimental design

Testing took place in a climate-controlled laboratory (temperature 20-21°C, relative humidity 50-55%) to standardise and control the sessions, providing clearer potential justification for further research using field protocols. Participants were instructed to avoid strenuous activity, refrain from caffeine and alcohol consumption, and consume a similar diet (including timing of dietary intake) for 24 h before each session. A within-participants design with each participant completing both trials enabled comparison of responses to both protocols. Using a random number generator (www.researchrandomizer.org), trial order was determined in a counterbalanced fashion. Within participants, trials were conducted at the same time of day at least three days apart. Session duration and mean intensity were matched as these influence exercise enjoyment [18 19]; standardising them better isolated the moderating effect of exercise method. Interactions during exercise between the researcher and participant were standardised and limited to required data collection.

Familiarisation trial

Anthropometric data were collected (body mass: SECA 803 weighing scales (SECA, Hamburg, Germany); height: SECA 213 stadiometer (SECA Hamburg, Germany)). Maximum HR (HR_{max}) was derived using the equation 208 - (0.7 x age) as this is the most valid age-related prediction equation (r = -0.90 between estimated HR_{max} and age) [20]. We did not directly measure HR_{max} via a maximal exercise test due to the insufficiently active nature of the participants and the likelihood that a maximal exercise test would not precede the use of HR-based intensity monitoring in real-world interventions of this nature.

Participants were introduced to the two-way non-rebreathing facemask (7450 Series V2, Hans Rudolph, Kansas, USA) and online gas analyser (Cortex Metalyzer 3B R2, Leipzig, Germany). They were then fitted with the facemask and mounted the motorised treadmill (ELG-70, Woodway, Germany) whereupon they walked at 3 $km.h^{-1}$ for six minutes.

Continuous walking trial

Participants warmed up by walking on the treadmill for 5 min at 3 $km.h^{-1}$. They were then fitted with a HR monitor (Polar Wearlink FS3, Finland) and the gas analyser facemask. Participants then walked for 30 min at 65-70% of predicted HR_{max} [21], in line with UK PA guidelines [1]. Starting speed was approximated based on individual HR responses in the familiarisation trial, with the aim to attain target HR within 60 sec. The investigator maintained target HR by adjusting treadmill speed according to live data from the HR monitor. On completion of the walk, the facemask was removed and participants walked for 5 min at 3 $km.h^{-1}$ to cool down.

Interval walking trial

The IW trial followed the same procedures as the CW trial, also lasting 30 min. Based on published IW protocols [22], the trial consisted of 6 x 3 min high-intensity walking (80% HR_{max}) interspersed with two minutes at low intensity (50% HR_{max}) [23]. The cumulative time spent at these two exercise intensities was designed to provide an overall session intensity of 68% HR_{max}, matching the CW trial.

Measurements

Heart rate was sampled at 1 sec intervals throughout exercise and presented as session means. Oxygen consumption and respiratory exchange ratio (RER) were exported as 1 min means. From this data, mean session VO_2 was calculated. Overall kilocalorie (kcal) expenditure and kcal expenditure attributable to carbohydrate (CHO) and fat metabolism for each minute of exercise was calculated using a non-protein RER table, which provides the caloric expenditure ($Kcal.min^{-1}$) and the contribution of CHO and fat ($Kcal.min^{-1}$) to this caloric expenditure at different RER values. The per-minute values for CHO and fat contribution were summed for each participant to calculate session means.

We assessed post-exercise enjoyment using the Physical Activity Enjoyment Scale (PACES) immediately following the cool-down in each trial [24]. The PACES consists of 18 items scored on a seven-point bipolar rating scale. The items were summed to produce an overall enjoyment score (range 18-126). Whilst enjoyment during exercise can differ from enjoyment prior to and after exercise [5], immediately following exercise is a well-established timeframe to measure enjoyment and affective responses [25].

Data analysis

Null hypothesis significance testing (NHST) readily yields false conclusions about the existence of an effect and the practical meaning of data; *P* values are also subject to large variation due to sampling variability [26]. As a result, eminent statistical organisations have recently published extensively on moving away from NHST [27]. This guidance recommends that researchers do not conclude anything about the practical or scientific importance of data based on statistical significance [27]. Alongside words of caution about NHST, researchers are recommended to analyse data in a way that provides meaningful information about precision and uncertainty in the data, and the likely population effect based on the data [28]. We take this approach in our analysis.

Data normality was assessed using the Shapiro-Wilk test. For HR and $\dot{V}O_2$, total kcal expenditure, kcal expenditure from CHO and fat, and overall PACES score, mean difference with 95% confidence limits (95%CL) between the two trials (IW – CW) was calculated. Cohen's *d* effect size (ES) for the mean difference was calculated using the equation:

$$d = \frac{\bar{X}_{IW} - \bar{X}_{CW}}{s_{mean}}$$

Where $\bar{X}_{IW}$ = mean of IW trial, $\bar{X}_{CW}$ = mean of CW trial, and s_{mean} = mean of the IW and CW standard deviations:

$$s_{mean} = \sqrt{\frac{s_{IW}^2 + s_{CW}^2}{2}}$$

Mean standard deviation represents the best estimate of the population standard deviation in within-participants designs, and is therefore the recommended standardiser for *d* [29]. For the mean difference ES, 95% confidence limits (95%CL) were estimated using the procedure described by Algina and Keselman [30]. The magnitude of ES was defined as trivial ($d < 0.2$), small ($d \geq 0.2$, <0.5), medium ($d \geq 0.5$, <0.8), and large ($d \geq 0.8$), expressed in units of standard deviation [31]. Differences between trials are reported in the text in the following manner:

[mean difference, 95%CL for that difference followed by units of measurement]; [Cohen's d ES for the difference, 95%CL for that ES]

Worked example:

2, 95%CL 0,4 beat.min^{-1}; *d* = 0.23, 95%CL 0.06, 0.41

RESULTS

Cardiometabolic demand

The second-by-second HR response to both protocols is in figure 1. These responses demonstrate the different activity profiles in the IW and CW trials. In the CW trial participants spent 91.3 ± 8.2% (range 87.6 – 97.8%) of total exercise time at target HR. In the IW trial, participants spent 65.5 ± 4.9% (range 59.9-70.1%) of total work time (18 min) at target HR ± 5 beat.min^{-1}, and 12.8 ± 11.0% (range 0-33.6%) of total recovery time (12 min) at target HR ± 5 beat.min^{-1}.

* FIGURE 1 HERE *

Mean HR and VO_2 during each trial is in figure 2. Mean HR showed a small positive difference in IW (69.7 ± 2.8% predicted HR_{max}) vs. CW (68.5 ± 2.9% predicted HR_{max}; 2, 95%CL 0, 4 beat.min^{-1}; *d* = 0.23, 95%CL 0.06, 0.41). Similarly, mean VO_2 showed a small positive difference (1.4 ± 2.2 ml.kg^{-1}.min^{-1}; 10.7, 95%CL 4.1, 17.3%; *d* = 0.36, 95%CL 0.05, 0.65) in IW vs CW.

* FIGURE 2 HERE *

Energy expenditure

In the IW trial, 81% of total kcal expenditure was from CHO and 19% from fat (*d* = 7.11). In the CW trial, 64% of total kcal expenditure was from CHO and 36% from fat (*d* = 2.47). Mean overall kcal expenditure, and kcal expenditure from CHO and fat during each trial is in figure 3. There was a medium positive difference in overall kcal expenditure in IW vs. CW (*d* = 0.58, 95%CL 0.33, 0.82). During IW there was a large positive difference in kcal expenditure from CHO (*d* = 1.06, 95%CL 0.57, 1.54) and a large negative difference in kcal expenditure from fat (*d* = -1.23, 95%CL -0.32, -2.11) vs. CW.

* FIGURE 3 HERE *

Post-exercise enjoyment

Post-exercise PACES scores are in figure 4. Post-exercise PACES score was moderately greater following IW vs. CW (d = 0.62, 95%CL 0.26, 1.09). Twelve participants rated IW more enjoyable than CW (mean increase in enjoyment 13.8, range 1-41 AU). Three participants rated CW more enjoyable than IW (mean increase in enjoyment 7.0, range 4-11 AU). One participant rated IW and CW as equally enjoyable.

* FIGURE 4 HERE *

DISCUSSION

This study is the first to investigate cardiometabolic and enjoyment responses to IW and CW in insufficiently active, healthy adults. In agreement with the hypotheses, IW elicited meaningfully greater energy expenditure and was meaningfully more enjoyable than CW.

Standardisation

Exercise duration and mean exercise intensity independently influence affective responses to exercise [18 19]. Therefore, it was important to standardise both to isolate the influence of IW vs. CW on outcome variables. Both trials lasted 30 min and mean HR showed only a small difference, which was likely due to the relatively slow HR reduction in the recovery periods of IW, as emphasised by the percentage of time spent at target recovery HR. Therefore, we successfully controlled the confounding factors of exercise duration and mean exercise intensity.

Energy expenditure

The small positive difference in mean $\dot{V}O_2$ in IW vs. CW elicited a medium positive difference in total kcal expenditure. This data suggests IW is a more efficient use of time than CW in terms of kcal expenditure. Two scenarios emphasise this point. Recommended weekly activity energy expenditure for reducing rates of cardiovascular disease and premature mortality is 1000 $kcal.wk^{-1}$ [32]. For participants in the current study to achieve this kcal expenditure they would need to perform CW for 217 $min.wk^{-1}$ (~7 x 30 min sessions); however, they would only have to perform IW for 184 $min.wk^{-1}$ (~6 x 30 min sessions; ~15% reduction in exercise time). This ~30 min difference represents 20% of the weekly aerobic physical activity recommended by the UK CMO, and could therefore be interpreted as a meaningful difference. Put another way, to achieve a target kcal expenditure in a given session, for example 250 kcal, would require participants in the current study to CW for 54 min but IW for 46 min (15% reduction in exercise time).

We acknowledge that the efficiencies of IW described above are modest relative to the potential time efficiency of 'traditional' HIIE vs. continuous exercise [33]. However, given the importance of lack of time as a barrier to exercise participation [34], modest contributions towards time efficiency and the provision of alternative exercise options are important. Furthermore, we contend that IW may be more acceptable to inactive individuals than traditional HIIE, due primarily to the lower intensity [9 35]. Better acceptability could facilitate better adherence to IW compared to traditional HIIE independent of time-efficiency issues; however, this needs investigation.

There was a large negative difference in fat utilisation in IW vs CW. On first consideration these metabolic responses do not favour IW as a method of body fat loss when considering the positive impact of exercise at maximal fat oxidation intensity on body composition [36]. However, a recent systematic review found that HIIE elicits similar reductions in body fat percentage, and larger reductions in absolute fat mass than MICE [37]. The positive effect of HIIE on body composition may be due to greater short- and longer-term post-exercise resting energy expenditure and therefore fat oxidation [38]. However, specific mechanisms likely depend in part on the intensity of the HIIE protocol. Nevertheless, these findings show that meaningful reductions in body fat are achievable via exercise that is sub-optimal for in-exercise fat metabolism. It is unlikely that the IW or CW protocol would result in prolonged elevations in resting energy expenditure. Coupled with the modest reduction in fat expenditure in IW vs. CW (~20 kcal), it is unlikely that differences in substrate use between trials would meaningfully influence body composition changes. Therefore, reduced fat metabolism in IW should not be viewed as a negative characteristic.

Post-exercise enjoyment

Overall PACES scores indicate that participants found IW more enjoyable than CW. This finding aligns with some existing work comparing HIIE with continuous exercise [15 39]. However, affective responses to and enjoyment of interval exercise is variable between individuals and influenced by protocol [9] and personal characteristics [12]. These factors can make it challenging to isolate moderators of enjoyment in insufficiently active adults. Nevertheless, 75% of our participants rated IW more enjoyable than CW. Some studies have reported greater post-exercise enjoyment following HIIE vs. continuous exercise in insufficiently active adults [25 39]. Greater enjoyment following IW may be due to the perception of this protocol as less monotonous than CW [15]. Given the association between affective judgement and PA [4], the more positive enjoyment reported in our IW trial indicates that participants may readily engage with it in the future. However, this hypothesis needs to be tested with a longer intervention. In addition, the influence of personal characteristics on perceptions of interval exercise [12] suggests that these perceptions may differ between samples, even if those samples are homogenous in terms of health and physical activity status. Therefore, it should not be assumed that all healthy, insufficiently active individuals would exhibit the same enjoyment responses to IW and CW that we report.

The 9-point mean difference between IW and CW represents a 7.1% difference on the PACES scale and the effect size of 0.62 could be described as a medium size difference. This difference is larger than the 6.7 point difference found between HIIE and moderate-intensity continuous exercise in a recent systematic review [40]. However, large variation means it may be too early to state whether this difference should be interpreted as meaningful in relation to long-term behaviour change, and this is an area for further investigation [40].

Strengths and limitations

The two trials were conducted in a controlled environment and matched for mean exercise intensity and duration, which allowed the isolation of the exercise method (interval vs. continuous) as the primary independent variable. Such control is important when generating data that is the first of its kind. Conversely, this level of control reduces the ecological validity of the data. We attempted to control pre-trial dietary intake, but were not able to objectively confirm that dietary standardisation occured. Finally, there was a gender imbalance in the study. However, exercise was standardised to individual intensities and the available evidence suggests no gender differences in responses to HIIE [41].

Implications and future research

As IW appears more enjoyable at the group level than CW it represents an alternative method of exercise that could encourage those who do not engage in CW to be more active. Interval walking also elicits greater energy expenditure than CW, making it a potentially useful option for those who find it difficult to make time for regular exercise. Walking is low-cost, requires no specialist equipment and is accessible to a majority of the population, making these practical implications relevant for a large number of people. Future work should A) unpick the moderating factors behind insufficiently active individuals' preference for IW or CW so this knowledge can be leveraged to provide more targetted and, hopefully, successful exercise prescription, B) consider the acute influence of different IW protocols on cardiometabolic demand and enjoyment in insufficiently active individuals, and C) implement IW interventions that establish the effect of IW on cardiometabolic health, body composition, and future exercise behaviour in insufficiently active individuals. Ultimately, it may be that IW could be included within physical activity guidelines if further research demonstrates that in comparison to CW (i) greater health benefits can be achieved for the same time exercising, (ii) similar health effects can be achieved but in a more time-efficient way, or (iii) greater enjoyment leads to more sustained long-term activity behaviour.

CONCLUSION

We present novel empirical data to show that IW elicits meaningfully greater energy expenditure and is more enjoyable than CW in insufficiently active, healthy adults. In our sample most people preferred IW, however it is likely that "one size does not fit all", and finding the right activity for people may be the key to enjoyment and sustained activity.

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Geolocation Information

The research was conducted in Edinburgh, Scotland. Participants were recruited from the local area. Specific nationalities were not a focus of the research and were not recorded.

Disclosure of interest

The authors report no conflicts of interest.

Data availability

Data are available upon reasonable request. The available data includes deidentifed participant descriptive data, and deidentifed Excel files containing the raw data used to generate the results for all outcome variables presented in this study. Please contact the corresponding author, Dr Shaun Phillips, for further information (shaun.phillips@ed.ac.uk).

FIGURE CAPTIONS

Figure 1: Mean (± SD) second-by-second heart rate responses in the CW (A) and IW (B) trials.

Figure 2: Mean (± SD) heart rate (A) and VO_2 (B) in the IW and CW trials. Grey lines are individual participant values. Mean (95%CL) difference in HR and VO_2 between the two trials (IW – CW) is plotted on the right y-axes.

Figure 3: Mean (± SD) Kcal expenditure (A), kcal expenditure from CHO (B), and kcal expenditure from fat (C) during IW and CW. Grey lines are individual participant values. Mean (95%CL) difference in each variable between the two trials (IW – CW) is plotted on the right y-axes.

Figure 4: Mean (± SD) post-exercise PACES scores following IW and CW. Grey lines are individual participant values. Mean (95%CL) difference in overall PACES score between the two trials (IW – CW) is plotted on the right y-axis.