

# The Impact of Moderate Intensities of Intermittent Interval Walking on Excess Post-exercise Oxygen Consumption

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**Abstract** This study evaluated the effects of continuous and intermittent walking on oxygen uptake ( $\text{VO}_2$ ), Rating of Perceived Exertion (RPE), and enjoyment during exercise, and excess post-exercise oxygen consumption (EPOC) and enjoyment after exercise. Methods: Four women and six men (mean  $\pm$  SD) aged  $24 \pm 5$  years completed four walking bouts in counterbalanced order matched for volume (90 metabolic equivalent [MET]-min): 1) one, 30-min continuous walking (CW) bout at moderate-intensity (3 METs;  $\approx 4.8$  km/h), 2) three, 10-min intermittent walking bouts (IW) at moderate-intensity (3 METs;  $\approx 4.8$  km/h) separated by 20 min of rest, 3) three, 8-min interval walking (IIW1) bouts at moderate-intensity (5 METs;  $\approx 6.4$  km/h: 3 METs;  $\approx 4.8$  km/h) separated by 20 min of rest, and 4) three, 8-min 40-s interval walking (IIW2) bouts at moderate-intensity (5 METs;  $\approx 6.4$  km/h: 3 METs;  $\approx 4.8$  km/h) separated by 20 min of rest.  $\text{VO}_2$  was measured during exercise and EPOC was measured for 20 minutes post exercise. RPE was assessed during exercise and enjoyment of exercise was assessed during- and post exercise. Results: Average accumulated  $\text{O}_2$  uptake during exercise and EPOC in IW ( $39,186 \pm 4,290$  mL; EPOC:  $2,582 \pm 339$  mL), IIW1 ( $36,964 \pm 3,789$  mL; EPOC:  $3,365 \pm 507$  mL), and IIW2 ( $35,804 \pm 3,979$  mL; EPOC:  $3,083 \pm 339$  mL) were higher (all  $p < 0.05$ ) than CW ( $24,500 \pm 2,427$  mL; EPOC:  $892 \pm 73$  mL). There were no differences in average RPE ( $p = 0.17$ ) or average enjoyment (all  $p \leq 0.05$ ) across time points or between conditions. Conclusion: In healthy, young adults, moderate-intensity intermittent walking and intermittent interval walking protocols resulted in higher energy expenditure during and after exercise – as reflected by accumulated  $\text{VO}_2$  uptake and EPOC, respectively – compared to moderate-intensity continuous walking matched by MET-min with no difference in enjoyment or RPE.

**Keywords:** oxygen consumption, metabolism, aerobic exercise, intermittent exercise, walking

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## 1. Introduction

The prevalence of overweight and obese adults is a public health challenge in the United States [1]. Adherence to current physical activity guidelines can provide an array of benefits to the public [2-4], however, many Americans do not meet the current physical activity guidelines [2-4]. Previously, the 2008 physical activity guidelines suggested segmented bouts of physical activity ( $\geq 10$  minutes) throughout the day can help mitigate the deleterious health effects that occur from extended sedentary behavior [4]. However, current guidelines removed the minimum, bout-duration threshold – affirming all physical activity is beneficial [2-4]. As such, segmented bouts of physical activity warrant more research due to the potential for people to accumulate

more, higher-intensity physical activity with similar subjective feelings of enjoyment and exertion; thus, conferring additional health benefits.

Walking is the most-common form of weight-bearing exercise which presents low risk, cost, and minimal equipment. Additionally, walking is relatively easy to implement in daily activities and is tolerable for sedentary individuals [5,6]. Lack of time is the most-cited barrier as to why Americans do not meet the minimum physical activity guidelines [7]. Conversely, previous research has indicated that multiple bouts of intermittent physical activity ( $\leq 10$  min) may provide equal or greater health benefits than more time-consuming, continuous exercise, and may be more tolerable, especially for sedentary individuals [8,9]. For example, several studies have assessed the metabolic and caloric expenditure differences in continuous and intermittent exercise of the same intensity, which have revealed intermittent exercise may

elicit a higher excess-post exercise oxygen consumption (EPOC) [9-20]. Therefore, study results indicating intermittent exercise may increase EPOC and overall caloric expenditure are promising in that individuals can engage in the exercise for a brief period while also expending more calories.

While these previous studies provide useful data on effects of intermittent versus continuous exercise, there are a limited number of studies investigating the acute effects of various bouts and speeds of intermittent and interval walking exercise on oxygen consumption, EPOC, and kilocalorie (kcal) expenditure. Peterson et al. [18] examined three bouts of 10-min intermittent walking versus one 30-min continuous bout of moderate-intensity to reveal the intermittent walking was as beneficial for caloric expenditure as the continuous bout. Campbell et al. [11] had healthy men perform a continuous and two intermittent exercise sessions that each expended 150 kcal to demonstrate high-density lipoprotein subfraction at 24 and 48 hours after continuous and intermittent walking were increased. Kaminsky et al. [15] demonstrated greater kcal expenditure after two bouts of 25 minutes of running versus a single bout of 50 minutes of running. Lyons et al. [17] found three, 10-min bouts of upper-body exercise elicited a higher combined EPOC magnitude than a similar intensity (60% peak oxygen uptake [ $VO_{2peak}$ ]) continuous bout of 30 min of upper-body exercise. Almuzaini et al. [10] found a higher combined 20-min EPOC magnitude after two 15-min cycling bouts ( $7,410 \pm 1,851$  mL) than after one 30-min cycling bout ( $5,278 \pm 1,305$  mL) of moderate-intensity [10]. Similarly, Potteiger et al. [20] investigated the effects of one 30-min, two 15-min, and three 10-min walking protocols (all at 70%  $VO_{2max}$ ) on EPOC to find the cumulative 20-min EPOCs from the intermittent exercises (two 15-min;  $3,247 \pm 1,327$  mL; three 10-min;  $4,060 \pm 1,055$  mL) were higher than the 20-min EPOC ( $1,848 \pm 1,586$  mL) after the continuous exercise (one 30-min bout). Goto et al. [21] had participants perform three 10-min bouts and a single bout of 30 min cycle ergometry exercise to find greater fat usage in the intermittent trials. Moreover, Mitchell et al. [9] included three walking conditions, consisting of 30-min continuous, and two bouts of interval walking with high-moderate: low-moderate intensities to conclude interval walking caused a greater  $VO_2$  and EPOC in the two interval walking conditions. More recently, a study by Ko et al. [16] compared 30 minutes of continuous to three, 10-min bouts of treadmill exercise at 60% of  $VO_2$  reserve in fit college-aged individuals. The results revealed during rest and exercise, oxygen uptake and energy expenditure were not different, however, during recovery, oxygen uptake and energy expenditure were higher in the intermittent than continuous protocols, with the fat oxidation rate higher in the intermittent bout. Together, these studies suggest equivalent or additional benefits to engaging in intermittent exercise versus continuous exercise for energy expenditure; however, variable walking protocols are absent in the literature.

Americans report exercise to be stressful on the mind and body, so it may be perceived as painful and unenjoyable [22,23]. Because of the possible negative perceptions of physical activity and exercise, this can consequently lead to less participation in physical activity,

which increases risk of chronic disease and injuries [24]. Thus, it is important for individuals to enjoy and feel positive affect about their physical activity engagement because this may increase their participation in the physical activity [25].

Walking can be a form of low-, moderate-, or vigorous-intensity exercise [3] that elicits high enjoyment levels, remembered pleasure, and forecasted pleasure in adults aged 18-40 years old [26]. Having positive responses to physical activity can increase self-efficacy, which augments the likelihood of performing the physical activity [27-29]. Low, moderate, and vigorous intensities of exercise have been explored and majority of studies now agree that engaging in higher intensities of physical activity will elicit better physiological health benefits, while enjoyment reports between lower and higher intensities have been similar [30-33]. In addition, research reports greater self-efficacy and intention [34] and enjoyment [35] to participate in future walking bouts when multiple, shorter bouts of intermittent walking were performed compared with one 30-min bout. Therefore, the effects of different intermittent bouts and speeds of walking on enjoyment and cardiometabolic demand should be assessed in future research.

In summary, studies examining the acute effects of performing intermittent versus continuous training have shown that intermittent exercises may elicit higher cumulative EPOC than a single continuous bout of exercise [10] [15-17] [20], while higher intensities of exercise may elicit better health outcomes with similar or higher enjoyment ratings than continuous exercise [30-33]. However, these previous studies have not included multiple different bouts of walking on  $VO_2$ , EPOC, and perceptual responses. Hence, additional intermittent and interval bouts (e.g., time, durations, and intensities) of walking exercise need to be explored so the physiological and perceptual effects of walking can be better understood.

Therefore, the primary purposes of this study were to examine exercise  $VO_2$ , EPOC, RPE, and enjoyment responses of one 30-min continuous, three 10-min continuous walking protocols, three 8-min intervals, and three 8-min 40-s intervals, of equal volume. Because previous research has demonstrated higher  $VO_2$  and EPOC [9] [16] and similar or higher enjoyment responses [34,35] in intermittent than continuous exercise, it was hypothesized that the intermittent walking protocols would elicit higher exercise- and post-exercise  $VO_2$ , higher EPOC values, and similar enjoyment responses compared with the continuous walking protocol.

## 2. Materials and Methods

### Participants

Six men and four women were recruited and completed this study. After completing the informed consent process, a Physical Activity Readiness Questionnaire and medical history questionnaire to classify them based on the American College of Sports Medicine's (ACSM) risk classification [36]. Current physical activity and fitness levels of each participant were obtained via the International Physical Activity (short version) Questionnaire [37] and a modified Balke-Ware Treadmill

Protocol [38], respectively. Low or moderate risk participants with a cardiorespiratory fitness level < 70<sup>th</sup> percentile were eligible to participate in the study. This low-risk delineation was an inclusion factor because this type of training would be most suitable for those who are less fit. Descriptive data are located in Table 1.

**Table 1. Descriptive characteristics of participants (men: n = 6; women: n = 4)**

| Variable                 | Mean $\pm$ SD   |
|--------------------------|-----------------|
| Age (y)                  | 24 $\pm$ 5      |
| Height (cm)              | 171.0 $\pm$ 6.9 |
| Body mass (kg)           | 77.3 $\pm$ 21.8 |
| Waist circumference (cm) | 78.1 $\pm$ 12.2 |
| Hip circumference (cm)   | 99.3 $\pm$ 12.0 |
| % Body fat               | 10.7 $\pm$ 4.3  |
| IPAQ MET-min/wk          | 3804 $\pm$ 1847 |

### Protocol

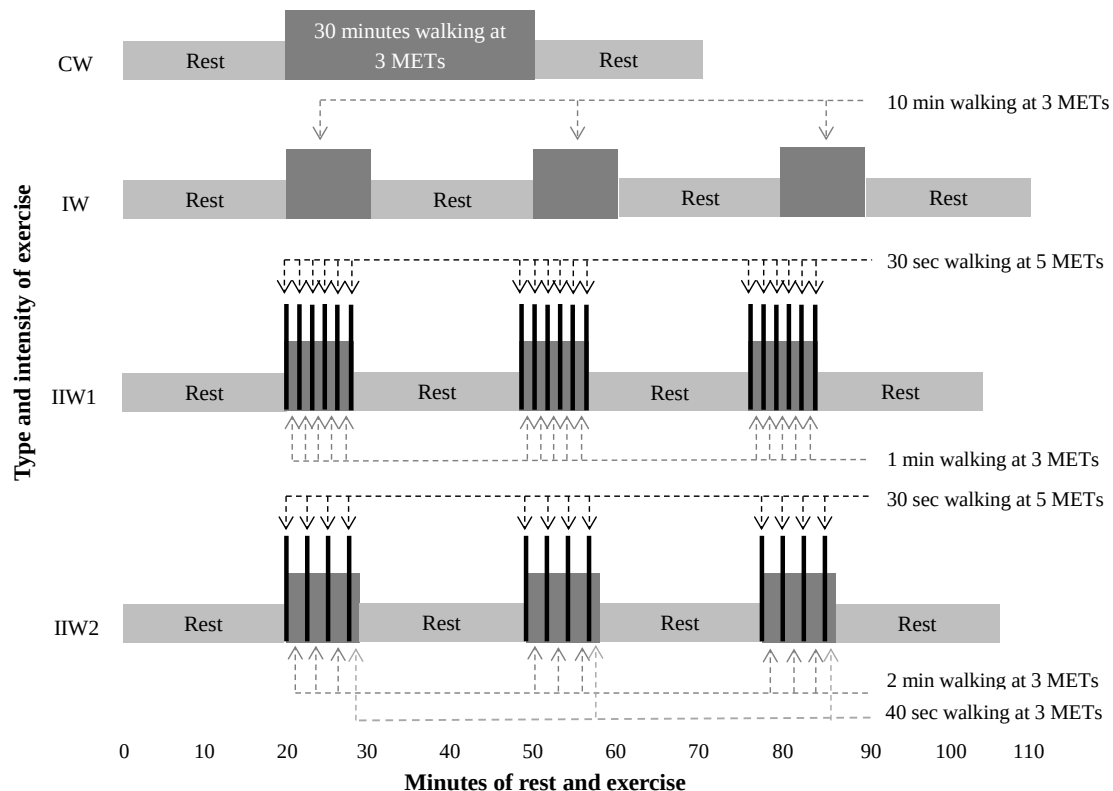
Prior to arrival, participants were asked to avoid consumption of food during the preceding two hours. Verification of pre-test guideline adherence was assessed before each trial via a 24-hour history form. At the initial session, height, weight, hip and waist circumference, and percent body fat were measured via a scale (Tanita BWB-800, Japan), stadiometer (Seca, Gaysumills, WI), measuring tape (Gulick II Measuring Tape, Gaysumills, WI), and sum of three skinfolds [39,40], respectively. An experienced technician collected all measurements based on ACSM guidelines [36].

Participants completed one continuous, one intermittent, and two, intermittent-interval walking protocols, each consisting of the same volume (90 metabolic equivalent [MET]-min). The walking protocols were performed on a treadmill (Quinton, Seattle, WA) at 0% grade in a controlled temperature environment ( $\approx 22$ -23 °C). Walking

protocols were performed within one hour of arrival at the initial session and separated by a minimum of 48 hours, but no more than one week. Each counterbalanced treatment order was assigned to participants randomly.

Figure 1 provides a visual schematic of the four walking protocols, including continuous walking (CW), intermittent walking (IW), intermittent interval walking 1 (IIW1) and intermittent interval walking 2 (IIW2). CW, IIW1, and IIW2 protocols were utilized in a previous study [9], but this research did not segment the walking protocols with rest in between walking bouts. For example, in the IW1 condition used by Mitchell et al. [9] participants completed 18 back-to-back intervals of walking. The present investigation completed three sets of six intervals of walking with 20 minutes of rest between walking bouts. In addition, the present methods added the IW protocol to the data set to determine the differences of multiple different walking protocols. The 20 minutes of rest between bouts was utilized because this duration of rest was used by Mitchell (2017) [9,20].

VO<sub>2</sub> was measured using a metabolic cart (TrueMax 2400, Parvo Medics, Sandy, UT); values were averaged every 30 s. Baseline VO<sub>2</sub> was measured continuously in the supine position over 20 min; VO<sub>2</sub> was determined from averaging the final 5 min of 30-s averages [41]. Exercising VO<sub>2</sub> during each walking protocol was calculated as VO<sub>2</sub> during walking minus VO<sub>2</sub> at baseline. RPE [42] was measured in 5-min intervals during walking. Following each bout of walking, EPOC was recorded over 20 min by measuring VO<sub>2</sub> in the supine position [20] and data were recorded every 5 min. Enjoyment was measured using the Exercise Enjoyment Scale (EES) [43] immediately after each bout of exercise for each condition.



**Figure 1. Protocol Design**

### Statistical Analyses

Accumulated O<sub>2</sub> uptake during exercise and EPOC (both in mL) were calculated from area-under-the-curve [44]. These data, along with average HR, RPE, and enjoyment during and after exercise from each treatment were compared using one-way repeated measures analyses of variance (ANOVAs). Two-way repeated measures ANOVA (treatment × time) was used to analyze EPOC between trials and over time. When applicable, pairwise comparisons were analyzed using a Bonferroni post-hoc procedure. Statistical Package for the Social Sciences v. 22 (SPSS; Armonk, NY) was used for all data analyses, and an alpha level of 0.05 was used for all hypothesis tests

- CW = 30-min bout at 3 METS (4.8 km/h) followed by 20 min of EPOC measurement.
- IW = 3x10-min bouts at 3 METS. Bouts 1 and 2 were separated by 20-min rest and bout 3 was followed by 20-min EPOC measurement.
- IIW1 = 3x8-min bouts of cycled work with 30 s:60 s at 5 METS (6.4 km/h):3 METS of work:active recovery cycles. Bouts 1 and 2 were separated by 20-min rest and bout 3 was followed by 20-min EPOC.
- IIW2 = 3x8-min 40-s bouts of cycled work with 30 s:120 s at 5 METS:3 METS of work:active recovery. Bouts 1 and 2 were separated by 20-min rest and bout 3 was followed by 20-min EPOC measurement.

## 3. Results

Figure 2 illustrates participants expended more energy ( $p < 0.001$ ) (as reflected by accumulated O<sub>2</sub> uptake) during IW (Mean ± SD) (39,186 ± 4,290 mL), IIW1 (36,964 ± 3,789 mL), and IIW2 (35,804 ± 3,979 mL) compared to CW (24,500 ± 2,427 mL) of the same work volume (90 MET-min). IW, IIW1 and IIW2 did not differ (all  $p > 0.05$ ).

A similar pattern was observed for total EPOC. IW (2,582 ± 339 mL), IIW1 (3,365 ± 507 mL), and IIW2 (3,083 ± 339 mL) elicited higher cumulative 20-min EPOC values than CW (892 ± 73 mL) (vs. IW:  $p = 0.002$ ; vs. IIW1:  $p = 0.003$ ; vs. IIW2:  $p < 0.001$ ). There were no differences between IW and IIW1, IW and IIW2, or IIW1 and IIW2 (all  $p \geq 0.08$ ). These differences in EPOC were driven by the first 5 min following the exercise. After the first 5 min post-exercise, EPOC was not different between treatments (all  $p > 0.05$ ).

Despite greater exercising O<sub>2</sub> uptake and EPOC values in the IW, IIW1, and IIW2 conditions compared to CW, overall average RPE was not different ( $p = 0.17$ ) by treatment. The mean RPEs for the walking protocols were 8 ± 1 (CW), 8 ± 1 (IW), 8 ± 1 (IIW1), and 9 ± 1 (IIW2). Similarly, there were no statistical differences ( $p \geq 0.32$ ) in enjoyment levels across time points or between conditions (Table 2).

Table 2. Exercise Enjoyment Scale Results

| Variable        | CW        | IW        | IIW1      | IIW2      |
|-----------------|-----------|-----------|-----------|-----------|
| Pre-exercise    | 4.7 ± 0.9 | 4.7 ± 0.9 | 4.9 ± 0.8 | 4.5 ± 0.8 |
| During-exercise | 4.7 ± 0.8 | 4.5 ± 0.7 | 4.9 ± 0.9 | 5.8 ± 0.9 |
| Post-exercise   | 4.9 ± 0.9 | 4.6 ± 0.7 | 4.8 ± 0.8 | 4.7 ± 1.0 |

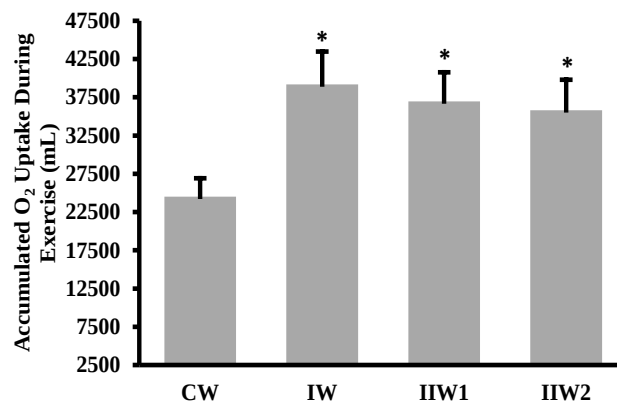


Figure 2. Energy expenditure (reflected by Accumulated O<sub>2</sub> uptake) during continuous, intermittent, and intermittent interval walking for 90 MET-min. CW = continuous walking, IW = intermittent walking, IIW1 = intermittent interval walking protocol one and IIW2 = intermittent interval walking protocol two. \*Different from CW ( $p < 0.05$ ).

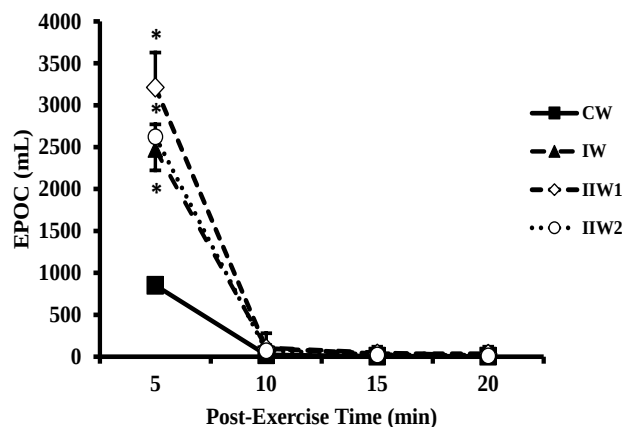


Figure 3. Cumulative 5-min EPOC values during the 20-min recovery period following continuous, intermittent, and intermittent interval walking for 90 MET-min. CW = continuous walking, IW = intermittent walking, IIW1 = intermittent interval walking protocol one and IIW2 = intermittent interval walking protocol two. \*Different from CW ( $p < 0.05$ ).

## 4. Discussion

The purpose of this study was to compare accumulated O<sub>2</sub> uptake during and post-exercise and EPOC between four walking protocols: a continuous 30-min moderate-intensity (3 METS) walking bout (CW), three moderate-intensity (3 METS) 10-min intermittent walking bouts (IW), three 8-min bouts moderate-intensity (30 s at 5 METS:60 s at 3 METS cycles) intermittent interval walking (IIW1), and three 8-min 40-s bouts moderate-intensity (30 s at 3 METS:120 s at 5 METS cycles) intermittent interval walking (IIW2), all of the same volume (90-MET-min). In line with our hypotheses, the primary finding was that all intermittent exercise conditions (IW, IIW1, and IIW2) elicited higher accumulated VO<sub>2</sub> during exercise than CW. Similarly, in the first five min and in the total 20 min following exercise, EPOC values were greater in IW, IIW1, and IIW2 than CW. Another important finding was no differences in perceived exertion or enjoyment demonstrated between any of the conditions. The protocol of the present investigation includes a similar methodology



and the same participants as a previous study [9]. Importantly, the current protocol includes three bouts that include 20-min rest periods between the intervals of walking, which are segmented into three separate bouts instead of being completed all at once - segmented. In addition, the present protocol added the IW condition, which was not implemented in the previous manuscript.

#### *Energy expenditure during exercise*

We speculate the reason for higher oxygen consumption during intermittent exercises compared with the continuous exercise was twofold: 1) IW, IIW1 and IIW2 reflect EPOCs from the previous bouts of exercises and 40-minutes of additional rest time between segmented bouts; 2) A higher intensity (i.e., speed) of exercise (interval walking of 3 METs and 5 METs compared with sustained walking at 3 METs) was performed in the intermittent interval walking protocols (IIW1 and IIW2). The rapid component of EPOC is often contributed to the oxygen debt experienced immediately after the exercise bout and is associated with greater kcal and fat usage [45]. These results suggest the three intermittent walking treatments accumulated additional EPOC following the previous bouts of moderate-intensity walking which elevated the accumulated oxygen consumed during exercise. The increases in  $\text{VO}_2$  values caused by the rapid EPOC component during multiple intermittent exercise bouts are similar to what Potteiger et al. [20] reported in females. Additionally, our results agree with Francis et al. [35], which found higher during exercise kcal expenditure in healthy adults, aged  $25.3 \pm 11.1$  years and with Mitchell et al. [9], which demonstrated greater  $\text{VO}_2$  after interval exercise compared with continuous [9] [35]. However, other studies found no difference in  $\text{VO}_2$  and energy expenditure during exercise between continuous and intermittent exercise bouts [14] [16] [18] [46].

#### *Excess post-exercise oxygen consumption (EPOC)*

The present study supports the observation that there is minimal increase in  $\text{VO}_2$  after exercises of lower exercise intensities [47]. Moreover, the present investigation demonstrated the intermittent walking conditions elicited a greater rise in EPOC than the CW condition for at least 5 min. Because the three intermittent walking protocols elicited a greater EPOC than the CW condition, this suggests that, as aforementioned, preceding walking bouts may cause an increased EPOC more than continuous bouts of exercise. Previous research has agreed that intermittent exercises elicit higher cumulative EPOC values compared to continuous exercises [9] [12-14] [16] [17] [19] [20]. Potteiger et al. [20] demonstrated higher energy was expended post exercise after intermittent exercise compared with continuous exercise in women. Lyons et al. [17] revealed higher cumulative EPOC after three 10-min arm exercises compared to one 30-min bout of arm exercise of the same intensity. Mitchell et al. [9] revealed greater EPOC in college-aged individuals after interval walking compared with continuous walking. Ko et al. [16] compared one 30-min to three 10-min bouts of treadmill exercise at 60%  $\text{VO}_2$  reserve on energy expenditure and EPOC to find the intermittent exercise contributed to greater EPOC and during exercise energy expenditure than the continuous exercise. Jung et al. [14] concluded that three bouts of 10 minutes of cycle ergometry exercise

at 60% of  $\text{VO}_{2\text{max}}$  caused greater EPOC than one bout of 30 minutes of continuous exercise at the same intensity. Although in the present investigation, the intensity according to the METs were the same (moderate intensity is 3 to 5.9 METs) for all conditions, the speed of walking in the IIW1 and IIW2 cycled intervals of faster and slower to produce MET levels 5 and 3, respectively; thereby eliciting a higher intensity than in the IW and CW conditions. In addition to exhibiting an increase in energy expenditure after intermittent exercise of the same intensity as continuous, other research has revealed higher intensity exercise will increase the EPOC compared to lower intensities [12,13] [19]. Gore et al. [12] calculated exercise intensity to explain five times more of EPOC than total work completed or exercise duration. Likewise, Phelain et al. [19] reported a higher EPOC after cycling at 75% versus 50%  $\text{VO}_{2\text{max}}$  of equal work volume. Accordingly, Jung et al. [13] found that interval cycle ergometry exercise performed at 80% of  $\text{VO}_{2\text{max}}$  for 2 min, followed by 40%  $\text{VO}_{2\text{max}}$  for 1 min, and 80%  $\text{VO}_{2\text{max}}$  for 3 min compared to 30 min at 60%, revealed a higher EPOC. These findings on EPOC and high-intensity exercise provide reasoning as to why IIW1 and IIW2 elicited higher EPOC values. However, these results are contrary to Tucker et al. [48], that concluded EPOC after sprint interval exercise and high-intensity exercise did not elicit greater EPOC and energy expenditure than a steady-state exercise bout.

The increase in EPOC in the intermittent conditions occurs because, due to the oxygen deficit from the previous exercise bout, sympathetic nervous system activity is increased which raises fat utilization and energy consumption, similar to interval exercise [49,50]. EPOC replenishes energy after exercise for the following reasons: to replenish the muscles with myoglobin to resynthesize depleted adenosine triphosphate (ATP), to re-supply oxygen in the blood [51], and to compensate for increased mitochondrial oxygen consumption during exercise and to restore oxidative phosphorylation ATP generation [52], [53]. These mechanisms result in higher consumption of oxygen after exercise is completed, which is displayed as EPOC [54,55].

When we examined this data in mL/min of oxygen consumption during exercise the following was revealed: CW: 816.7; IW: 1306.2; IIW1: 1369.0; IIW2: 1118.9. Therefore, the interval groups elicited a greater oxygen consumption per minute during exercise. In addition, when we totaled the oxygen consumption (during exercise + EPOC) in mL/min, the following was revealed: CW: 507.8; IW: 464.0; IIW1: 438.4; IIW2: 422.7. These results demonstrate CW to have the highest mL/min of oxygen consumption because CW had the lowest amount of rest time (40-min less rest time) within the protocol. Indeed, the total time of measurement for CW was 50 minutes (30 minutes exercise, 20 minutes post-exercise). Whereas the interval walking conditions had greater measurement time (IW: 90 min; IIW1: 87 min; IIW2: 92 min). Hence, on average, the total amount of oxygen consumed was higher in all the interval walking conditions than the CW condition.

#### *Total Kilocalories Expended*

The cumulative exercise kcal usage above baseline kcal energy expenditures for the entire exercise session (exercise + EPOC) were 127 kcal for CW, 209 kcal for IW, 202 kcal

for IIW1, and 194 kcal for IIW2. If an adult performed the walking protocols five days per week for four weeks, they would accrue monthly walking kcal expenditures of 2,540 kcal (CW), 4,176 kcal (IW), 4,032 kcal (IIW1), and 3,888 kcal (IIW2). IW and IIW1 would have a similar monthly energy expenditure, followed by IIW2 and CW. This hypothetical monthly energy expenditure illustrates that intermittent and intermittent interval walking may provide adults with an exercise prescription that is superior to continuous walking to improve cardiovascular function.

#### *Perceived Exertion and Enjoyment*

Participants exhibited no differences in the perceptual parameters consisting of perceived exertion and enjoyment between the treatments. It is important to understand which exercise protocols elicit higher enjoyment because previous studies have demonstrated individuals who experience positive affect of exercise have greater adherence to the activity [25] [56]. Many adults in the United States do not meet physical activity guidelines [3,4] [57], there is a high prevalence of cardiovascular disease [57], overweight and obesity [1], and other public health challenges [59]. Because there is an inverse association between physical activity and cardiovascular disease, overweight, and obesity [59,60], it is imperative that adults find exercises which they enjoy to improve health. In the current investigation, although participants were exercising at higher intensities, according to O<sub>2</sub> uptake, in two conditions (IIW1, IIW2), no differences in perceived exertion or enjoyment were experienced. Research has shown intensity of physical activity may be associated with better health outcomes [8], [61,62]. Therefore, this data is promising, such that intermittent and/or intermittent interval walking for shorter durations, some at higher intensities, may be utilized to make greater improvements in health while being perceived as just as enjoyable compared with more time-consuming and lower-intensity continuous walking. Similar studies as the present demonstrated post-exercise enjoyment to be moderately greater in intensity-matched interval walking compared with continuous walking and [35] and no differences in perceived exertion or enjoyment between continuous walking and interval walking in young adults [9].

#### *Limitations and Future Research*

Although this protocol and data are informative and novel, it is not without limitations. The walking protocols utilized in this experiment only used three different intermittent walking bouts. There are several different interval and segmented permutations that should be investigated, and researchers should attempt to adjust for the contribution of resting energy expenditure in segmented protocols in a manner that still captures intermittent EPOC. Additionally, due to the sample being limited to healthy young adults, external validity is limited for application to other groups. Future studies should examine adults who have health risks, are more diverse, and have lower fitness levels.

#### *Conclusion*

In conclusion, for healthy, young adults, moderate-intensity walking protocols that were performed intermittently elicited higher energy expenditure during

and after exercise, measured by accumulated O<sub>2</sub> uptake and EPOC, respectively, compared to continuous walking of a similar volume. Additionally, enjoyment of the exercise was similar between continuous and intermittent walking bouts, suggesting intermittent exercise may be a favorable method to increase participation in physical activity. This research has indicated that multiple bouts of moderate-intensity exercises of  $\leq 10$  min may provide novice exercisers and those with cardiometabolic risk factors and disease with a tolerable start to an exercise regimen, which may also address the “lack-of-time” barrier and increase one’s intention to exercise.

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## Statement of Competing Interests

Authors have no competing interests or conflicts of interest.

## List of Abbreviations

CW: Continuous walking  
 IW: Intermittent walking  
 IIW1: Intermittent interval walking 1  
 IIW2: Intermittent interval walking 2  
 VO<sub>2</sub>: Oxygen uptake  
 EPOC: Excess post-exercise oxygen consumption  
 RPE: Rating of perceived exertion  
 METs: Metabolic equivalent of task

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