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Exercise Intensity Influences NEAT in Overweight and Obese Adults

Running title: Exercise Intensity Influences NEAT

This study was funded by Institute of Health and Biomedical Innovation, Queensland University of Technology; and King Saud University.

Abstract:

Purpose: To determine the effect of acute bouts of moderate- and high-intensity walking exercise on non-exercise activity thermogenesis (NEAT) in overweight and obese adults.

Method: 16 participants performed a single bout of either moderate-intensity walking exercise (MIE) or high-intensity walking exercise (HIE) on two separate occasions. The MIE consisted of walking for 60 minutes on a motorized treadmill at 6 $km \cdot h^{-1}$. The 60-minute HIE session consisted of walking in 5-min intervals at 6 $km \cdot h^{-1}$ and 10% grade followed by 5-min at 0% grade. NEAT was assessed by accelerometer on three days before, the day of, and three days following the exercise sessions.

Results: There was no significant difference in NEAT vector magnitude ($counts \cdot min^{-1}$) between the pre-exercise period (days 1-3) and the exercise day (day 4) for either MIE or HIE protocol. In addition, there was no change in NEAT during the three days following the MIE session, however NEAT increased by 16% on day 7 (post-exercise) compared with exercise day ($P = 0.32$). However during the post-exercise period following the HIE session, NEAT was increased by 25% on day 7 compared with the exercise day ($P = 0.08$), and by 30-33% compared with pre-exercise period (day 1, day 2 and day 3); $P = 0.03, 0.03, 0.02$, respectively.

Conclusion: A single bout of either MIE or HIE did not alter NEAT on the exercise day or on the first two days following the exercise session. However, monitoring NEAT on a third day allowed the detection of a 48-h delay in increased NEAT after performing HIE. A longer-term intervention is needed to determine the effect of accumulated exercise sessions over a week on NEAT.

Keywords: Non-exercise activity thermogenesis; Compensatory response; Accelerometer; Weight loss.

Introduction

Paragraph number 1 The prevalence of obesity, a major risk factor in the development of type 2 diabetes and increased morbidity and mortality, has increased rapidly in recent decades (7,27). Exercise represents an important intervention for weight loss through the potential to raise energy expenditure, assuming that energy intake is not increased concomitantly (5). However, the results of some exercise interventions are disappointing as some participants do not achieve the theoretical weight loss associated with the expected increase in total energy expenditure (TEE) (30,32). One possible cause of this is compensation for the energy expenditure during the exercise sessions through a reduction in energy expenditure from non-exercise activity thermogenesis (NEAT) (12). As a result of this compensation, TEE is unchanged and thus weight loss may not occur (10).

Paragraph number 2 NEAT is defined as the energy expenditure of all physical activities other than volitional exercise, such as the activities of daily living, small muscle movements, spontaneous muscle contraction, and postural maintenance (17). The role of NEAT in the development of obesity has been highlighted by the fact that a failure to increase NEAT levels may result in fat gain in susceptible individuals and the maintenance of leanness in others (17,18). The energy cost difference due to time spent in different postures such as standing, sitting, or lying may be as large as 2000 $kcal \cdot day^{-1}$ between two people of similar body size (16). The variability in fat gain has been found to be inversely related to a participant's ability to increase NEAT (17), suggesting that promoting increased NEAT along with structured exercise may be a promising strategy to increase overall TEE and thus weight loss.

Paragraph number 3 Although several studies have observed that participants reduce their NEAT during the remainder of the day or on non-exercise days as a response to exercise training (6,11,15,19,22,23,25,28), the factors that may influence this compensatory response remain unknown. A possible factor that may affect how individuals respond to exercise is the intensity at which the exercise is performed. In elderly cohorts, it has been observed that an addition of structured exercise training to the day was compensated for by a significant decrease in NEAT (6,22). The proposed reason for this compensatory decline in NEAT was the high level of exercise intensity. However, because a comparison with NEAT subsequent to moderate- or low-intensity exercise was not undertaken, the influence of exercise intensity per se in elderly participants could not be confirmed. Evidence of the differential impact of exercise intensity on NEAT has been shown in a study of obese boys. Kriemler et al. (15) examined the impact of a single exercise bout on energy expenditure and NEAT in 14 obese children (10-15 yr). NEAT on the day following the exercise session was increased when exercise was of moderate-intensity but decreased following an intense bout of exercise. Further, the limited duration used to measure NEAT in this study (one day before and one day after the single bout of exercise) may not provide a reliable estimate of usual daily physical activity (29), or could fail to detect a delayed change in NEAT due to the brevity of the measurement period after the exercise. It is commonly recognised that delayed onset of muscle soreness (DOMS) can persist for days after an unaccustomed exercise bout (2,9). In a review of the literature, Cheung et al. (2003) explain that the intensity of discomfort increases within the first 24 hours following cessation of exercise, peaks between 24 and 72 hours, subsides and eventually disappears by 5–7 days post-exercise. Therefore, measuring NEAT for a longer duration (e.g. across a 7-d monitoring protocol) will provide more information about the influence of different exercise intensities on NEAT and its patterns relative to time (29). The aim of this study, therefore, was to determine whether an acute laboratory-based intervention comparing moderate- and high-intensity exercise would differentially influence NEAT in overweight and obese adults. NEAT was assessed using an accelerometer for three days before, the day of, and three days following, the exercise sessions. It was hypothesised that both walking exercise bouts would decrease NEAT on the day of exercise and on the three days after the structured exercise session. It was further hypothesised that the two walking exercise bouts would affect NEAT differentially, with the high-intensity session resulting in greater compensation.

Methods

Paragraph number 4 16 overweight and obese male adults (mean ± SD: age 26.5 ± 3.0 yr; height 170 ± 8.4 cm; body mass 87.3 ± 22.0 kg; body mass index 30.0 ± 5.6) took part in this study. All participants were sedentary, and participated in less than one hour per week of physical activity. Written informed consent was obtained for all participants before the start of this study. Approval was obtained from the Human Research Ethics Committee of the Queensland University of Technology.

General design

Paragraph number 5 This study was conducted using a cross-over repeated measures design in which each participant served as his own control (Fig. 1). Participants took part in two different conditions; moderate-intensity walking exercise (MIE) and high-intensity walking exercise (HIE). In both conditions, NEAT was measured via accelerometry for three consecutive days prior to the exercise manipulation on the day of, and for the following three days after the walking exercise bout.

A single walking exercise bout at moderate- and high-intensity

Paragraph number 6 Two walking exercise bouts at either moderate- or high-intensity were performed between 6:00 and 8:00 am one week apart. The MIE session consisted of walking for 60 minutes on a motorized treadmill at 6 $km \cdot h^{-1}$. The HIE session consisted of 60 minutes of interval walking at 6 $km.h^{-1}$ and a 10% grade for five minutes followed by five minutes at 0% grade; the theoretical vertical displacement was 300 m. We have previously shown this walking speed occurs between the "walking for pleasure" pace and maximal walking speed over a 2 km trial for obese adults (8). All participants, with the exception of one individual (BMI = 45 kg/m^2) who walked at 5 $km \cdot h^{-1}$, were able to walk for 60 min at 6 $km \cdot h^{-1}$. A Polar HR monitor (Polar Electro Oy, Kempele, Finland) was worn during both walking exercise bouts. For the MIE session the average HR for the group was 127 ± 12.8 bpm, whereas for the HIE session the group had an average HR of 132 ± 15 bpm during the 5-min horizontal walking and 163 ± 14 bpm during the 5-min walking at a 10% incline (the overall HR for HIE was 147 ± 14 bpm). The energy costs of the exercise sessions were calculated using ACSM equations for estimating the total rate of energy expenditure (gross VO_2), in $ml \cdot kg^{-1} \cdot min^{-1}$ (1). The energy costs of the exercise sessions were calculated using ACSM equations for estimating the total rate of energy expenditure (gross VO_2), in $ml \cdot kg^{-1} \cdot min^{-1}$ (1).

The estimated gross VO_2 determined by the ACSM walking equation:

Walking VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$) = [(Speed ($m \cdot min^{-1}$) × 0.1) + (Speed ($m \cdot min^{-1}$) × grade (%) × 1.8) + 3.5].

The estimated gross VO_2 was then converted to energy expenditure ($kcal \cdot min^{-1}$) using the following equation:

Exercise energy expenditure ($kcal \cdot min^{-1}$) = ((estimated gross VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$) × body weight) / 1000) × 5 × exercise duration (minute).

The conversion of VO_2 to energy expenditure is based on the assumption that each litre of O_2 is equivalent to 5 kcal. Although it is accepted that this value overestimates the energy cost of activities characterised by a respiratory quotient (RQ) < 1.0, when RQ is not known, as was the case for the current study, the value of 5.0 $kcal \cdot L^{-1}$ is recommended (1).

Paragraph number 7 Mean energy costs of the MIE and HIE sessions were 353 ± 89 kcal and 589 ± 149 kcal, respectively. To minimize the potential confounding effect of weekends, day 1 for MIE and HIE was randomly scheduled on either Monday or Friday. Therefore, the day of the exercise manipulation (day 4) was randomly scheduled on either Thursday or Monday, and the order of the two exercise manipulations was counterbalanced. By doing so, weekends for the first half of participants were after the exercise day, and weekends were before the exercise day for the other half. The order of the conditions was counterbalanced. The day of the week of the walking exercise session was fixed within participants. All participants were familiarized with the motorized treadmill by walking slowly for 5-min.

NEAT assessment

Paragraph number 8 NEAT was measured using a tri-axial accelerometer: StayHealthy RT3 (StayHealthy, Inc., Monrovia, CA). The device weighs 65.2 g (7.1 × 5.6 × 2.8 cm) and measures acceleration in three individual planes (horizontal, vertical, lateral), and then integrates accelerations to yield one value; the vector magnitude (VM). In order for the data to be collected for 7 days, the epoch duration was set at 1 min. The RT3 accelerometer was worn by all participants for a period of seven consecutive and complete days including 2 weekend days (three days before the experiment, the day of an exercise laboratory visit and the following three days). Participants were instructed to clip the accelerometer to the waistband in line with their right hip and to wear the device at all times except during sleeping or when there was risk of contact with water. In order to interpret potential irregularities in the data and/or adjust for non-wearing times, all participants were required to complete a daily self-report log indicating the time they woke in the morning, the time they placed the RT3 on their hip, the time they removed the RT3, the time they went to bed, and the time and reason for any unusual circumstances which caused the removal of the RT3. All participants met the criteria of having valid RT3 data as defined as having 10 h or more of movement registered (3). 60 consecutive minutes with no movement data (zero activity) was considered to be non-wearing time which was subtracted from 24 hours. For RT3, a VM between 0 to 20 counts per minute was defined as a threshold of sedentary activity (13). Each participant used the same RT3 unit at each assessment (14).

Paragraph number 9 The RT3 data of the exercise task was excluded from the data of the exercise day and then adjusted by using the following formula: total vector magnitude (counts $\cdot d^{-1}$) = [(total vector magnitude (counts $\cdot d^{-1}$) / 23) × 24]. Prior to using the RT3, it was initialised with the participant's age, gender, height, and weight. When removed from the participant the activity data were down-loaded to a computer using Microsoft Excel©.

Paragraph number 10 As there are differences in biomechanical efficiency of movement between individuals, calculation of an activity-related time equivalent based on accelerometry (Arte*ACC*) was also calculated for each individual; this is defined as an index of time spent in accelerometer-measured activity equivalent to that of a reference exercise activity (26). Arte*ACC* was calculated as: Arte*ACC* (min $\cdot d^{-1}$) = [total daily activity counts (ACs) (counts $\cdot d^{-1}$)/ reference exercise ACs (counts $\cdot min^{-1}$)]. The reference exercise ACs was determined by calculating the mean of activity counts obtained during MIE session (i.e. walking at constant speed at 0% grade).

Statistical analysis and treatment of data

Paragraph number 11 Statistical analyses were carried out with SPSS for Windows (Version 16). Data were expressed as mean values and standard deviations (SD). To compare scores on the total daily VM (counts·min^{-1}), NEAT VM (counts·min^{-1}), and Arte*ACC* (min·d^{-1}) across all days (day1 to day14) a one-way repeated measures ANOVA was conducted. If there was no effect of time, the total daily VM (counts·min^{-1}) and NEAT VM (counts·min^{-1}) in days 1 to 3 (pre-exercise) and days 5 to 7 (post-exercise) were pooled and used for later analyses.

Paragraph number 12 A two-way repeated measures analysis of variance (ANOVA) (2 (exercise intensity protocols) × 3 (times: 3-day pre-exercise, exercise day, and 3-day post-exercise) was conducted to assess the impact of two different exercise intensity protocols (moderate- and high-intensity walking exercise) on the total daily body movements VM (counts·min^{-1}), NEAT VM (counts·min^{-1}), and Arte*ACC* (min·d^{-1}) across three periods (3-day pre-exercise, exercise day, and 3-day post-exercise). Statistical significance was accepted if $P < 0.05$.

Results

Paragraph number 13 Mean (±SD) NEAT VM (counts·min^{-1}) and Arte*ACC* (min·d^{-1}) for MIE and HIE protocols: pre-exercise days (d1-d3), exercise days (d4) and post-exercise days (d5-d7) are shown in Table 1. Individual data of NEAT VM (counts·min^{-1}) across 7 days for MIE and HIE are also shown (see figure, Supplemental Digital Content 1, which shows all individual data of NEAT VM (counts·min^{-1}) for MIE across all days (day1 to day7); see figure, Supplemental Digital Content 2, which shows all individual data of NEAT VM (counts·min^{-1}) for HIE across all days (day1 to day7)).

Paragraph number 14 When comparing NEAT VM (counts·min^{-1}) across the 14 days of testing, a repeated measures one-way ANOVA revealed that there was a significant effect of time (P = 0.001) (Fig. 2). Post-hoc comparison indicated that there was no significant differences in NEAT VM (counts·min^{-1}) between d1-d3 (pre-exercise period) in both MIE and HIE protocols. There was also no significant change in NEAT VM (counts·min^{-1}) on the exercise day after performing structured exercise session in both MIE and HIE protocols (113.5 ± 43.5; 117.7 ± 39.8, respectively). NEAT VM (counts·min^{-1}) did not differ significantly between d5-d7, the three days following the structured exercise in the MIE protocol. Despite NEAT VM (counts·min^{-1}) increasing by 16% on d7 (pre-exercise) compared with the exercise day in the MIE protocol, it was not statistically significant (P = 0.32). NEAT VM (counts·min^{-1}) did not differ significantly between the first two days (d5 and d6) following the HIE session. However, NEAT VM (counts·min^{-1}) increased by 25% on d7 (pre-exercise) compared with the exercise day (P = 0.08), and by 30-33% compared with pre-exercise period (P = 0.03, 0.03, 0.02), respectively. The increase in NEAT VM (counts·min^{-1}) observed on d7 (pre-exercise) in HIE protocol was not affected by the order that the two exercise intensities were performed.

Paragraph number 15 When the 60-min of prescribed exercise data (counts·min^{-1}) were included in the day of exercise, total daily movement (NEAT plus 1h exercise) on the exercise day increased significantly in both MIE and HIE protocols, although total daily movement on the two exercise days did not differ (204.3 ± 50; 209.6 ± 48, respectively – see Fig. 3). For both MIE and HIE protocols, total daily movement (counts·min^{-1}) on the exercise days was increased significantly by 48% compared with pooled pre-exercise period value (d1-d3) and by 44% compared with the pooled post-exercise period value (d5-d7).

Paragraph number 16 In order to have a reliable estimate of NEAT and despite the fact that there was significant difference in NEAT VM (counts·min^{-1}) on d7 in the HIE protocol, d1-d3 (pre-exercise) and d5-d7 (post-exercise) were pooled for both exercise intensities (Fig. 4). A two-way repeated measures analysis of variance was conducted and revealed no significant effect for an exercise intensity × time interaction; F (2, 14) = 0.06, P = 0.94. The ANOVA also revealed no significant main effect of time (F (2, 14) = 1.09, P = 0.33), with no changes in NEAT VM (counts·min^{-1}). There was no significant change in NEAT VM (counts·min^{-1}) between MIE and HIE; F(1, 15) = 0.34, P = 0.56.

Paragraph number 17 When Arte*ACC* index was calculated, the main effect for exercise intensity, time (pre-, the same day and post-exercise), and the interaction effect between exercise intensity and time remained statistically non-significant; F(1, 15) = 0.68, P = 0.42; F(2, 14) = 1.67, P = 0.22; F(2, 14) = 0.16, P = 0.85, respectively (Fig. 5).

Discussion

Paragraph number 18 While our results provide further support for the importance of exercise to increase the net daily movement of overweight and obese participants, the primary finding from this study was that the exercise sessions had no immediate debilitative effect on NEAT on the day of exercise or on the following 2 days. However, there was a delayed increase in NEAT 48 h after performing a 60-min HIE session. With the exception of Manthou et al. (19), no previous study has investigated the acute effect of exercise intensity on NEAT in obese adults. Our results are contrary to the findings of Goran and Poehlman (6) in the elderly, Kempen et al. (11) in obese women, and Kriemler et al. (15), in obese boys. The reduction in NEAT following intense exercise session was partially explained by the possibility that NEAT may decline due to fatigue and discomfort. This notion was supported by Goran and Poehlman (6) who found a significant average decrease [62% (571 ± 386 to 340 ± 452 $kcal \cdot day^{-1}$)] in NEAT in response to endurance training in elderly men. The compensatory decline in NEAT during the remainder of the day may have occurred because of the high intensity of the exercise (85% of $\dot{V}O_{2max}$). Consequently, elderly people fatigued during the remainder of the day. Results are also consistent in obese women who participated in moderate aerobic training (50-60% $\dot{V}O_{2max}$). The combination of exercise-induced energy expenditure with an energy-restricted diet did not accentuate weight loss because the training was partly compensated for by a decrease in NEAT outside the training sessions (11). In obese children, NEAT was increased when exercise was of moderate-intensity but decreased following an intense bout of exercise. This finding supports the contention that moderate-intensity exercise is better tolerated than high-intensity exercise, especially for obese individuals. Previous research suggests that time spent in moderate-intensity activities is potentially more effective for increasing overall levels of energy expenditure compared with high-intensity activities (31). The findings of the current study did not concur with results of earlier studies.

Paragraph number 19 The difference in duration of imposed exercise could explain the different outcome between our study and those of Kriemler et al. (15) Goran and Poehlman (6). Furthermore, the mode of exercise (i.e. cycle ergometer) used in both earlier studies was different to the treadmill walking in our study. Cycling could cause more localised muscle fatigue than treadmill walking (4), however this comparison has not been undertaken. Most importantly, the choice of method and period measured to detect change in NEAT is critical. In our study, accelerometry with time interval was chosen to allow us to detect changes in NEAT, especially during the period that follows exercise. This would be impossible to determine using the doubly labelled water technique (DLW), as in the Goran and Poehlman study (6), because the technique cannot discriminate between activity types and exercise time intervals. Also, in our study, NEAT was measured for 3 days following each exercise session which provided the opportunity to detect changes in NEAT 48-h after the exercise session. If the choice of measurement period was limited to 24-h following the exercise session as in the study of Kriemler et al. (15), any changes in NEAT beyond 24-h would go undetected.

Paragraph number 20 Although we detected changes in NEAT 48-h after the exercise session, it is not clear why there was a delayed increase in NEAT on day 7. One explanation could be the difference in physical activity between weekdays and weekend days (20). However, this is not possible in this study because for half the participants, day 7 was a weekend day, and for the other half it was a week day. Therefore, the phenomenon of delayed increase in NEAT needs further examination.

Paragraph number 21 The effect of exercise training on NEAT has been reported in a number of studies, but the findings are inconsistent. For instance, Meijer et al. (24) investigated the effect of a 20-wk endurance training program on NEAT using accelerometer measured average daily metabolic rate in healthy people who were preparing for a half marathon. Although the accelerometer output increased significantly during the training program compared with baseline, the authors suggested that the increase was due to the extra activities comprising the training program and suggested that NEAT was not affected by the endurance training. Another recent study reported no compensatory effect of a short-term (8d) exercise programme on NEAT in a lean, moderately-active group of men and women. Therefore, a reduction in body mass, observed in women only, was not explained by a change in NEAT but rather by a compensatory increase in food intake (21). In contrast a recent study reported that overweight and obese women compensated by being less active outside exercise sessions and achieved lower than predicted fat loss as result of the 8 weeks of exercise intervention, although NEAT was not measured (19). However, each of these studies only measured NEAT at two time-points, namely baseline and at the end of the exercise intervention. The acute effect of exercise on NEAT was not investigated. It would be of interest to know what temporal changes in NEAT were evident during the intervention.

Paragraph number 22 In conclusion, the results of our study indicate no adverse effect of exercise on NEAT in the days following a 60-min walking session. Further, we found a differential effect of exercise intensity on NEAT 48 h following exercise in overweight/obese adults. Contrary to our hypothesis, the walking exercise resulted in an increase in NEAT in the third day after the exercise session, and this was most pronounced in the HIE condition. However, since the average value for both NEAT and ArtACC did not confirm the delayed increase in NEAT, this finding needs to be interpreted with caution. Moreover, since the aim of this study was to explore the acute effect of exercise intensity on NEAT in response to a single exercise session, the effects of 7d of continuous exercise still needs to be determined. These data have positive implications for the role of exercise in weight management. Despite a number of claims, imposed acute exercise does not appear to induce a compensatory reduction in NEAT in obese individuals. Therefore, a longer term study in this population is needed to determine the effect on NEAT following a number of exercise sessions.

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the present study do not constitute endorsement by the American College of Sports Medicine.

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FIGURES AND TABLES

Figure 1. Schematic overview of the study design.

(d: day, NEAT: non-exercise activity thermogenesis, MIE: Moderate-intensity walking exercise, HIE: High-intensity walking exercise)

Figure 2. Mean NEAT VM (counts·min^{-1}) during seven consecutive days in both MIE and HIE protocols.

Figure 3. Mean total daily movement (NEAT plus 1h exercise) on the exercise day for MIE and HIE protocols.

Figure 4. Mean NEAT VM (counts·min^{-1}) during pre-exercise (d1-d3 pooled), the exercise day (d4) and post-exercise (d5-d7 pooled) for MIE and HIE protocols.

Figure 5. Mean change in NEAT VM (counts·min^{-1}) based on activity-related time equivalent Arte*ACC* (min·d^{-1}) during days 1-7 for MIE and HIE protocols.

Table 1. Mean (± SD) NEAT and Arte*ACC* for the 3-day pre-exercise period, exercise day, and 3-day post-exercise period.

SUPPLEMENTAL DIGITAL CONTENT

Supplemental Digital Content 1.

FIGURE. Individual data of NEAT VM (counts·min^{-1}) for moderate-intensity walking exercise (MIE) across 7 days.

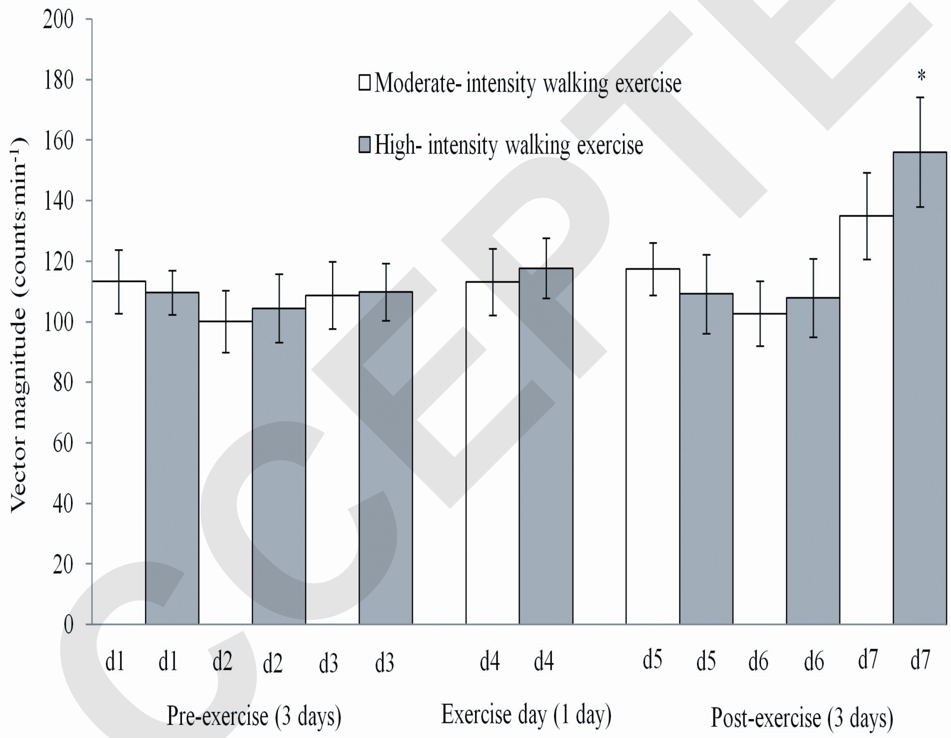
Supplemental Digital Content 2.

FIGURE. Individual data of NEAT VM (counts·min^{-1}) for high-intensity walking exercise (HIE) across 7 days.

Figure 1

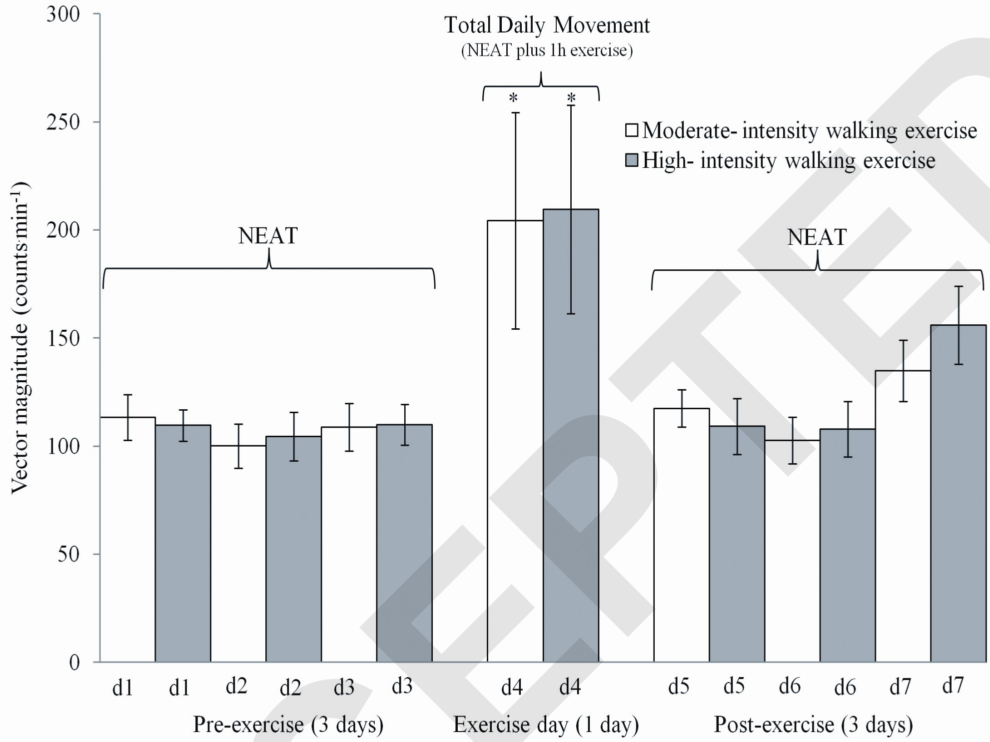
Moderate-intensity walking exercise							High-intensity walking exercise						
Pre-exercise			MIE session (60 min)	Post-exercise			Pre-exercise			HIE session (60 min)	Post-exercise		
d1	d2	d3	d4	d5	d6	d7	d1	d2	d3	d4	d5	d6	d7
Assessing NEAT for 7 consecutive days by accelerometer (RT3)							Assessing NEAT for 7 consecutive days by accelerometer (RT3)						

Figure 2



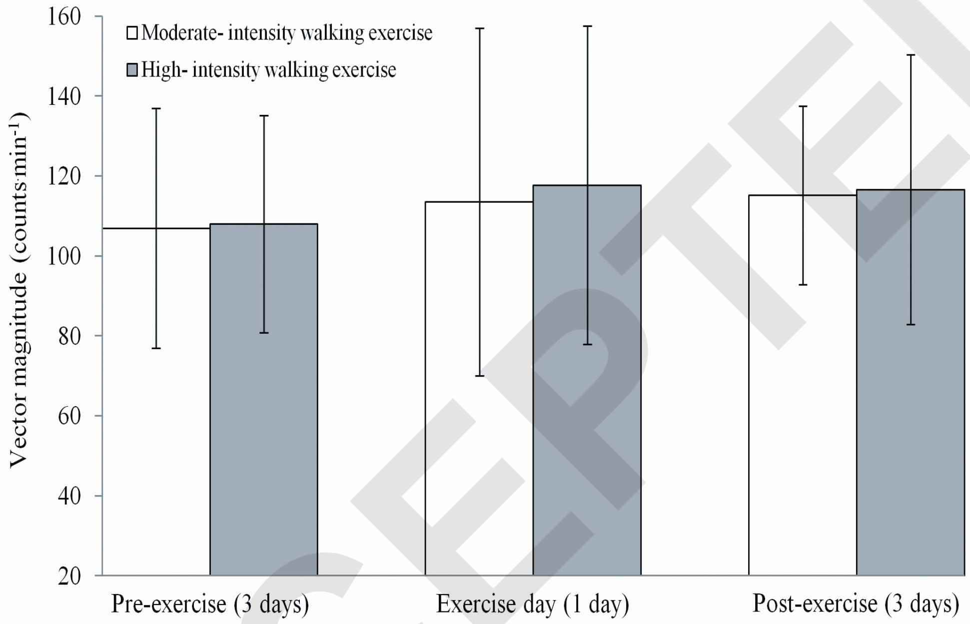
200
180
160
140
120
100
80
60
40
20
0
Vector magnitude (counts·min-1)
Moderate- intensity walking exercise
High- intensity walking exercise
*
d1
d1
d2
d2
d3
d3
d4
d4
d5
d5
d6
d6
d7
d7
Pre-exercise (3 days)
Exercise day (1 day)
Post-exercise (3 days)

Figure 3



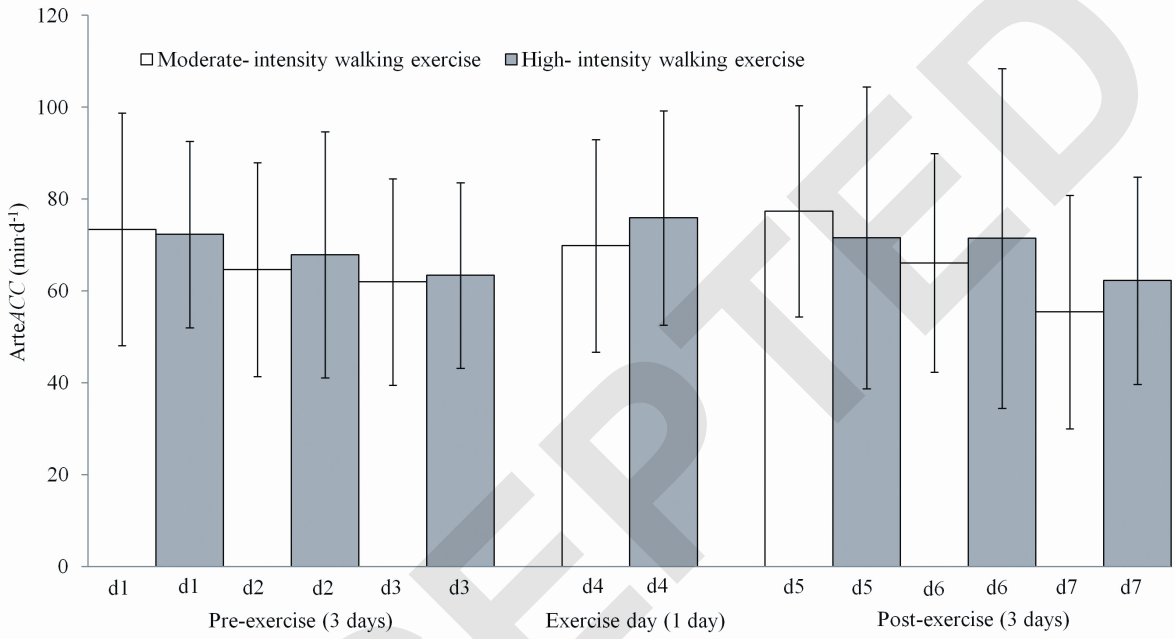
Total Daily Movement
(NEAT plus 1h exercise)
Moderate- intensity walking exercise
High- intensity walking exercise
Vector magnitude (counts·min⁻¹)
NEAT
NEAT
*
*
300
250
200
150
100
50
0
d1
d1
d2
d2
d3
d3
d4
d4
d5
d5
d6
d6
d7
d7
Pre-exercise (3 days)
Exercise day (1 day)
Post-exercise (3 days)

Figure 4



Moderate- intensity walking exercise
High- intensity walking exercise
Vector magnitude (counts·min-1)
160
140
120
100
80
60
40
20
Pre-exercise (3 days)
Exercise day (1 day)
Post-exercise (3 days)

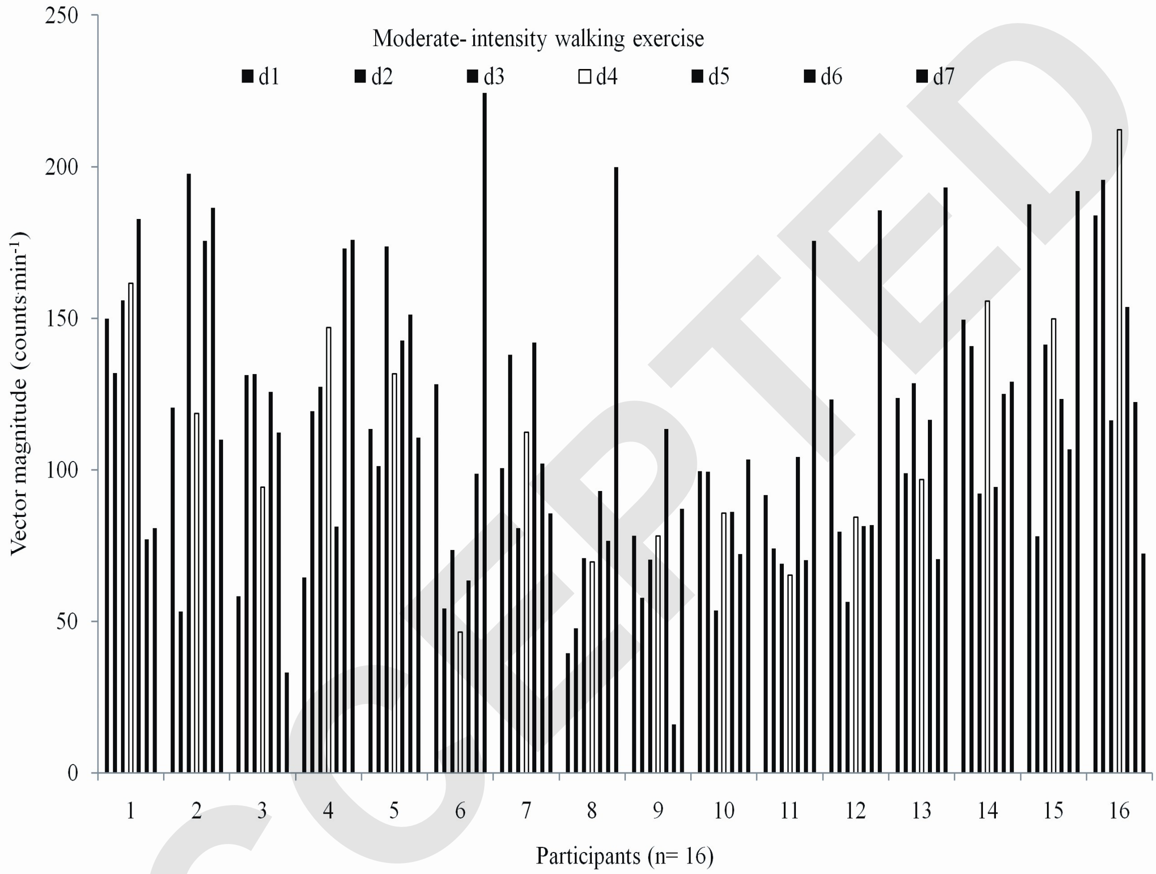
Figure 5



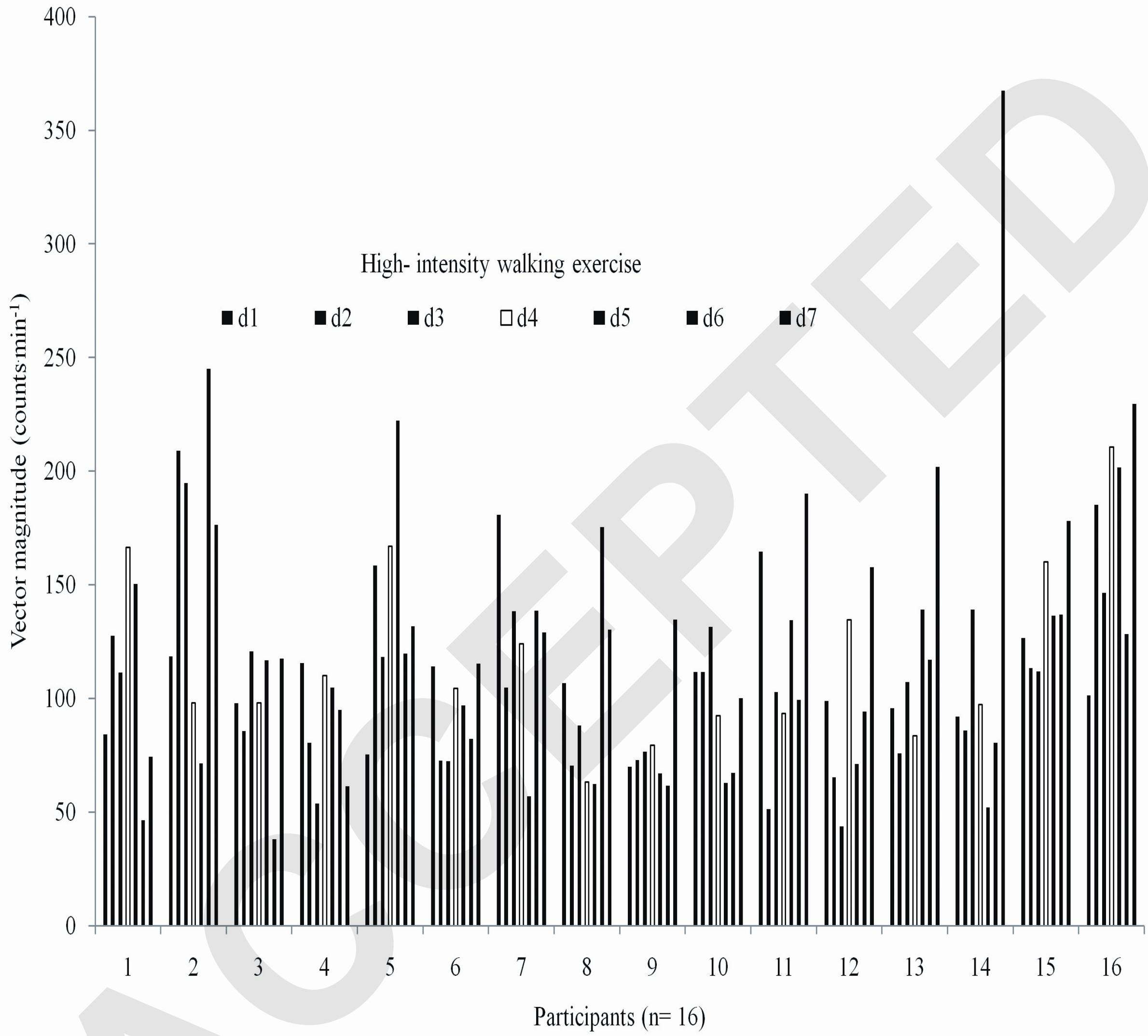
120
100
80
60
40
20
0
□ Moderate- intensity walking exercise
■ High- intensity walking exercise
ArteACC (min·d-1)
d1
d1
d2
d2
d3
d3
d4
d4
d5
d5
d6
d6
d7
d7
Pre-exercise (3 days)
Exercise day (1 day)
Post-exercise (3 days)

Moderate-intensity walking exercise (counts·min^{-1})			High-intensity walking exercise (counts·min^{-1})		
NEAT Pre-exercise (d1-3)	NEAT Exercise day (d4)	NEAT Post-exercise (d5-7)	NEAT Pre-exercise (d1-3)	NEAT Exercise day (d4)	NEAT Post-exercise (d5-7)
106.9 ± 30	113.5 ± 43.5	115.2 ± 22.3	108.0 ± 27.2	117.7 ± 39.8	116.6 ± 33.7
Moderate-intensity walking exercise (min·d^{-1})			**High-intensity walking exercise (min·d^{-1})**		
Arte*ACC* Pre-exercise (d1-3)	Arte*ACC* Exercise day (d4)	Arte*ACC* Post-exercise (d5-7)	Arte*ACC* Pre-exercise (d1-3)	Arte*ACC* Exercise day (d4)	Arte*ACC* Post-exercise (d5-7)
69.3 ± 16.8	69.9 ± 23.1	75.6 ± 14.3	70.7 ± 16.1	73.7 ± 23.7	76.0 ± 19.2

NEAT: non-exercise activity thermogenesis, Arte*ACC*: activity-related time equivalent based on accelerometry



Moderate- intensity walking exercise
d1
d2
d3
d4
d5
d6
d7
Vector magnitude (counts·min-1)
0
50
100
150
200
250
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Participants (n= 16)



High- intensity walking exercise
d1 d2 d3 d4 d5 d6 d7
Vector magnitude (counts·min⁻¹)
400
350
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Participants (n= 16)
ACCEPTED