Original Article

# Title: Real world, real people: Can we assess walking on a treadmill to establish step count recommendations in adolescents?

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# Abstract

**Background:** It is currently not known how much walking should be advocated for good health in an adolescent population. Step count recommendations for minimum time in moderate intensity activity have been translated predominantly from treadmill walking. The aim of this study was to compare the energy cost of walking on a treadmill with overground walking in adolescent girls. **Method**: Twenty six adolescent girls undertook resting metabolic measurements for individual determination of one MET using indirect calorimetry. Energy expenditure was subsequently assessed during treadmill and overground walking at slow, moderate and fast walking speeds for 4 – 6 minutes. Treadmill step rates were matched overground using a metronome. **Result**: The energy cost of treadmill walking was found to be significantly greater than and not equivalent to overground walking at 133step·min$^{-1}$ (equivalent to the fast walking pace) $\dot{V}O_2$ 3.90 [2.78 to 5.01] $P<0.001$, MAPE =18.18%, METs 0.77[0.54 to 1.00] $P<0.001$, MAPE =18.16%. The oxygen cost per step ( $\dot{V}O_2$ ml· step$^{-1}$) was significantly greater and not equivalent on the treadmill at 120 and 133step·min$^{-1}$, 0.43 [0.12 to 0.56] $P<0.05$, MAPE =10.12%, 1.40[1.01 to 1.76] $P<0.001$, MAPE =17.64% respectively. **Conclusion**: The results suggest that there is a difference in energy cost per step of walking on a treadmill and overground at the same step rate. This should be considered when utilising the treadmill in energy expenditure studies. Studies which aim to provide step recommendations should focus on overground walking where most walking activity is adopted.

# Introduction

Adolescent girls are insufficiently active which has serious implications for their current and future health (7, 41). Walking is recognised as an effective way of implementing regular, health enhancing physical activity into the daily routine of the general population (27) and in an adolescent population walking is a convenient alternative to active play and sports participation. In order to promote walking, researchers have sought to identify the required step count and step rate to achieve a health-enhancing number of steps and intensity of walking (1, 3, 24, 30, 35).

In adults 10,000 steps/day is considered sufficient to maintain health and this is considered equivalent to normal habitual activity (7,000 steps) plus 30 min of moderate intensity activity (3,000-4,000 steps) (33). There is conflicting evidence with regard to the number of steps required for health in children. Tudor-Locke et al (33) reported that 12,000 and 15,000 steps/day were sufficient for good health for girls and boys respectively whereas Duncan, Schofield and Duncan (9) reported 13,000 (girls) and 16,000 (boys) steps·day$^{-1}$. Although useful, these recommendations are appropriate for children but not for adolescents and whilst identifying the number of steps recommended is important, it is also pertinent to establish the step rate so that walking can be undertaken at a level of intensity beneficial for health. Step rate corresponding to moderate intensity walking in adults has been investigated in at least five prior studies (1, 3, 24, 30, 35). These studies were conducted in well controlled laboratory conditions on a treadmill (1, 24, 35), overground (3) and using both treadmill and overground (30). From these studies it has been suggested that a step rate of ≥100 steps·min$^{-1}$ is associated with moderate to vigorous intensity walking in adults and therefore recommended for health.

With regard to the stepping rate required to promote moderate intensity walking in adolescent girls there is limited data. Seven youth studies have provided data on step rate that reflect intensity of walking (11, 12, 14, 17, 22, 26, 34). While five studies have investigated walking on a treadmill (11, 12, 22, 26, 34) only one has investigated walking overground (17) and one has cross-validated treadmill walking overground (although treadmill step rate data were used) (14). Further only three of these studies (14, 26, 34) have directly assessed walking intensity (energy expenditure). However, it should also be noted that two of these studies (14, 34) have used estimated resting energy expenditure in participants under 18yrs to calculate METs. It is therefore difficult to accurately extrapolate step rate corresponding to moderate and moderate to vigorous intensity walking, due to the different intensity markers used and lack of direct assessment of energy expenditure.

A major limitation with several of these studies is the assumption that treadmill walking is equivalent in energy cost to overground walking. There are clear advantages to using a treadmill to assess walking, for example walking is not limited by space or environmental conditions, and speed can more easily be controlled. However, in adults, there is evidence to suggest that treadmill walking may overestimate the energy cost of walking overground (4, 6). For example, individuals tend to adopt an unnatural and less energy efficient walking pattern on a treadmill (4, 6). Consequently, the recommendation of 100 $\text{steps}\cdot\text{min}^{-1}$ may be an underestimation of the stepping rate associated with moderate intensity walking overground in adults. It is not known if walking on a treadmill accurately replicates walking overground in adolescent girls. Thus, in order to undertake studies to identify step guidelines in an adolescent population based on treadmill studies, it is important to first determine whether treadmill and overground walking are similar in terms of energy cost for the same step rate. The aim of this study was therefore to compare the energy cost of walking on a treadmill with overground walking in adolescent girls.

## Methods

A convenience sample of twenty-six adolescent girls aged between 12-15 yrs (mean±SD age = 14.01±0.56 yrs) took part in the study which was given ethics approval by the institution's research ethics committee. Data were collected from each participant on the same day, in the following order: a) anthropometric and resting metabolic rate measurements; b) three 6-min treadmill walking trials; c) three overground walking trials lasting a minimum of 4 min.

### ***Measures***

#### *Anthropometry*

Stature and body mass were measured using a seca portable stadiometer and seca 761 flat scales (seca, Birmingham, UK) respectively. Measurements were made according to the procedures recommended by the International Society for Advancement of Kinanthropometry. Measurements were repeated twice, and the mean was taken as the true measurement.

#### *Metabolic measures*

Gas exchange variables and heart rate were measured and displayed online using the Oxycon mobile portable metabolic cart (MS-CPX, Viasys Healthcare, Hoehberg, Germany). The participants breathed through an appropriately sized tight-fitting mask (Hans Rudolph ING, USA) with the total dead space volume, including turbine, of 120ml. The gas analyser, volume sensor and turbine were calibrated according to the manufacturer's specifications before each test. Oxygen uptake ( $\dot{V}O_2$) was measured continuously on a breath-by-breath basis and averaged over 5 seconds for data analysis.

*Step count measures*

Step counts were measured by real-time direct observation, using a hand tally counter (observed by two researchers). This method is considered to be an accurate way of directly measuring steps and is often used as a criterion measure against which other step measurement methods are compared (24, 30).

**Experimental protocol**

For the assessment of resting metabolic rate, $\dot{V}O_2$ was measured over a 20-min period while the participant sat quietly watching a DVD. $\dot{V}O_2$ was subsequently assessed during treadmill and overground walking trials. During the treadmill trials, participants completed three 6 minute controlled trials at 2, 3 and 4 mph respectively. The treadmill incline was set at 0%, which is deemed appropriate at walking speeds <6.5mph as there is no wind resistance (19). Following a ≈ 4minute warm up where participants practiced stepping onto and off the treadmill at all speeds, the participants were fitted with a heart rate monitor and the Oxycon metabolic system (weighing 1.2 kg), held by a harness, which slipped over the girls' shoulders and clipped into place securely without restricting movement. The participants were then asked to stand on the treadmill with a foot on either side of the belt, while it was set to the appropriate speed. Following a 5 second countdown, the participant stepped onto the treadmill and began walking. The event marker on the metabolic cart was pressed immediately prior to and following each trial, for later reference in the $\dot{V}O_2$ data. Treadmill speed was calibrated using a digital tachometer, twice during the first minute of each treadmill walking trial. Step rate was measured using two methods; total observed step count over the 6 minute trial, measured by hand tally and a 60 second stride rate taken during the fifth minute of each trial, which allowed an overground stride rate (stepping speed) to be prescribed. A 5-s countdown was given to each participant indicating when she should step off the treadmill. Within each trial, heart rate was recorded during the last 15 seconds of each minute, for determination of steady state (defined as a change of less than 5 beats per min) (2). An average of 5 minutes of static rest was taken between trials and 20 minutes between each walking mode (treadmill and overground).

Following the treadmill walking trials, participants completed three overground walking trials on a 34m indoor oval track, which was marked out. The treadmill step rate obtained from the 60-s hand tally count was prescribed for the overground walking trials to replicate the treadmill speed. This was accomplished by setting a clip-on metronome to the treadmill step rate and asking each participant to match their step rate to the metronome. Total number of steps were measured, using real time direct observation hand tally count by means of a researcher walking behind each participant counting steps taken. For logistical reasons, the overground walking trials were not limited to 6 minutes, as a complete number of laps had to be taken in order to provide a known distance from which the average walking speed could be calculated. Participants started and finished each trial at the same point and were informed by the researcher halfway round the last lap to stop at the finish line. In order to obtain steady state data, the participant walked for between 4 and 6 minutes. As with the treadmill trials the event marker on the metabolic cart was pressed immediately prior to and following each trial, for later reference in the $\dot{V}O_2$ data, and heart rate data were recorded during the last 15 seconds of each minute of the trials, to determine steady state.

## Data analysis

Hand tally counts observed from the two researchers were compared and an average taken if an exact match was not observed. Where step rate overground did not match the prescribed step rate (±10 steps·min-$^1$), data were excluded from further analysis (n=5). One MET was calculated individually as the mean $\dot{V}O_2$ for 5 min between the 10th and 14th min of the 20-min seated period using the Weir equation (39). For each walking trial (treadmill and overground), $\dot{V}O_2$ was determined for the final 2 min, and subsequently converted into METs. Oxygen cost per step was calculated for each walking trial. Descriptive statistics were expressed as mean ± standard deviation for the dependent variables. Differences in treadmill and overground response variables ($\dot{V}O_2$ and METs) were tested using a factorial repeated measures analysis of variance (ANOVA) and Bonferroni corrected post hoc pairwise comparisons. Partial eta-squared values ($\eta^2_p$) are reported as effect size estimates. The magnitude of the effect size for the partial eta-squared is 0.01 (small), 0.06 (medium), and 0.14 (large) (5). Agreement between the treadmill and overground response variables was also tested. Pearson correlations tested relative accuracy and initial agreement was obtained by Mean absolute percent error (MAPE). Equivalence testing using the TOST method was used to determine group level agreement (8,32). It is important with this testing approach to specify appropriate equivalence zones (8). However, there is no conclusive standard (21), therefore the equivalence zone was set at 10%. This is in line with prior studies (20, 21, 31, 40) which have used this method of analysis within physical activity research. All analyses were conducted using PASW Statistics version 18.0.0 (IBM Corp., Somers, NY). With exception of the Equivalence analyses which were conducted using Jamovi (18) version 0.8. Statistical significance was set at $p < 0.05$.

# Results

Twenty-one participants successfully completed all overground walking trials at the prescribed step rate to replicate treadmill walking speed. Five participants were excluded from further analysis as their step rate overground did not match the prescribed step rate (±10 steps·min-¹). There were no significant differences in physical characteristics and other outcome variables measured, between those participants that were not included and those included in the final analysis. Participants' physical characteristics and resting measures are presented in table 1.

[Table 1]

## Treadmill and overground response parameters

Table 2 presents response parameters during each walking trial. The results of the ANOVA show a significant main effect of condition (treadmill and overground walking) F (1, 19) = 10.74, *P* <0.01, $\eta^2_p$ =0.58; speed F (2, 38) = 243.15 *P* <0.01 $\eta^2_p$ =0.96 and interaction F (2, 38) = 71.16 *P* <0.01 $\eta^2_p$ =0.78on $\dot{V}O_2$ (ml·kg-¹·min-¹) and a significant main effect of condition F (1, 19) = 10.94, *P*<0.01, $\eta^2_p$ =0.36speed F (2, 38) = 125.75 *P* <0.01, $\eta^2_p$ =0.86 and interaction F (2, 38) = 70.91 *P* <0.01, $\eta^2_p$ =0.78 on METs. Significant differences between treadmill and overground walking were apparent at step rates (steps·min-¹) equivalent to the fast walking speed only. Despite matching step rate (steps·min-¹), walking speed at slow and fast pace was significantly different between conditions. The overground walking pace was significantly faster than treadmill walking in the slow walking trials and significantly slower in the fast walking trials.

## Treadmill and Overground agreement

Treadmill $\dot{V}O_2$ were moderately correlated with overground $\dot{V}O_2$ at all walking speeds (slow, moderate and fast) respectively ($r = 0.54$, $P=0.01$, $r = 0.64$, $P < 0.001$, $r = 0.54$, $P = 0.01$). Treadmill METs were moderately correlated with overground METs ($r=0.59$ $P<0.001$) at the slow walking speed and strongly correlated ($r = 0.81$, $P < 0.001$, $r = 0.77$, $P < 0.001$) at the moderate and fast walking speed. The MAPE was 10.92%, 8.8%, 18.18% and 10.95%, 9.25%, 18.16% for $\dot{V}O_2$ and METs at slow, moderate and fast walking speeds respectively. Table 3 presents the 10% equivalence zones and the associated 95% CI mean difference for each response variable. Treadmill walking was deemed equivalent to overground walking at 10% for $\dot{V}O_2$ and METs at slow and moderate walking speeds. Treadmill walking required a significantly greater energy cost and was not equivalent in terms of $\dot{V}O_2$ and METs when compared to overground walking during the fast walking trials.

[Table 2]

[Table 3]

## Oxygen Cost per Step

Figure 1 presents the oxygen cost per step, ( $\dot{V}O_2$ ml· step $^{-1}$) during each walking trial. Results of the ANOVA show a significant main effect of condition (treadmill and overground walking) F (1, 20) = 10.99, $P < 0.01$, $\eta^2_p = 0.35$ speed F (2,40) = 22.98 $P < 0.01$, $\eta^2_p = 0.53$ and interaction F (2, 40) = 44.99 $P < 0.01$, $\eta^2_p = 0.69$ on $\dot{V}O_2$ (ml·step $^{-1}$). The oxygen cost per step was significantly greater and not equivalent to overground (Table 3) during the moderate and fast treadmill walking trials.

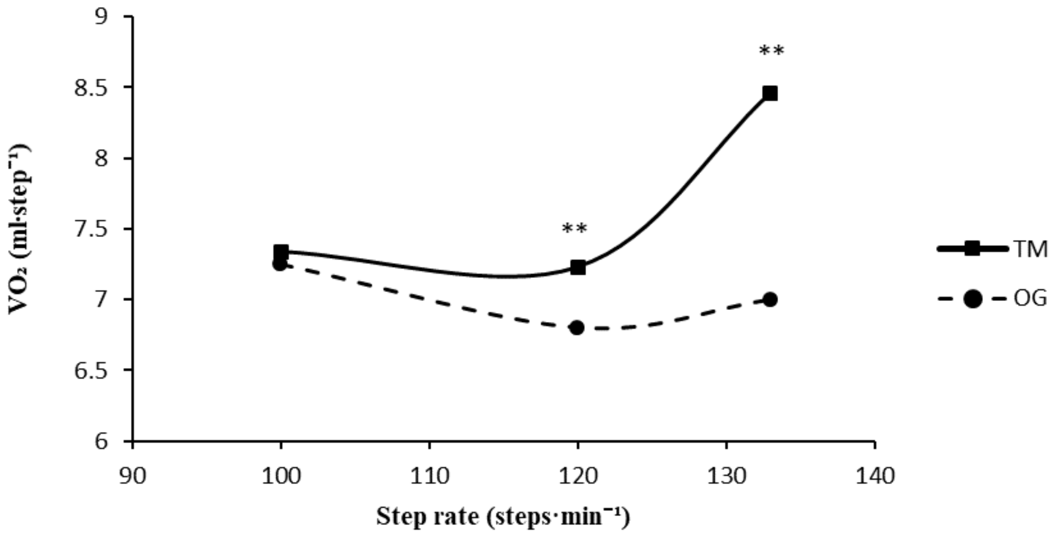

**Figure 1.** Comparison of the oxygen cost per step for the mean step rates during each walking trial for treadmill and overground walking.

TM = treadmill; OG = overground

**significantly higher than overground walking ($p < 0.01$)

## Discussion

In order to determine whether walking can be assessed on a treadmill to establish step rate recommendations, the current study has compared the energy cost for equivalent step rates during treadmill and overground walking in a group of adolescent girls. The results suggest that the energy cost of walking on a treadmill is greater than and not equivalent to walking overground at step rates thought to be representative of moderate to vigorous intensity walking in the youth population (11, 17, 26, 34). Although the energy cost for equivalent step rates were compared, rather than walking speed per se, the results of the current study are consistent with the findings of Parvataneni, Ploeg, Olney and Brouwer (28), Dal et al., (6) and Berryman et al., (4) who observed a greater metabolic energy cost during treadmill walking when compared to overground walking at both pre-selected (4) and self-selected (6, 28) walking speeds in adults (6) and older adults (4, 28).

## Step rate, Speed, Energy Cost Relationship

The mechanisms underlying the higher metabolic energy cost observed during treadmill walking in comparison to overground walking are complex and not well understood (4). Holt, Hamill and Andres (15) suggested that when individuals walk overground in a natural setting (i.e. real world setting) they adopt a preferred walking speed and step rate (frequency) to minimise the metabolic energy cost and maintain energy efficiency. Based on this hypothesis it has been suggested that the relationship between oxygen cost and step rate gives a U-shaped curve when walking speed is kept constant (15,16). Further Rose, Ralston and Gamble (29) suggested that during self-selected walking overground an individual's arms, legs and trunk are coordinated in such a manner that keeps vertical displacement to a minimum, thus maximizing metabolic economy. Therefore, when individuals are forced to walk at a slower or faster pace (e.g. on a treadmill), energy efficiency is reduced. While step rate to match walking speed between the two modes (treadmill and overground) was prescribed rather than self-selected in the current study, a mismatch in walking speed for the same step rate was observed during the slow and fast walking trials between the two modes (i.e. during the slow walking trial the girls walked faster overground than on the treadmill, but slower overground during the fast walking trial). This suggests that the girls adopted a more energy efficient walking pattern overground, by adjusting their gait (stride length) to a more natural, comfortable walking speed to match the prescribed step rate overground and may account for the large effect sizes observed for $\dot{V}O_2$, METs, $\dot{V}O_2$ ml· step $^{-1}$. It also suggests that the treadmill may have forced the girls into walking at an unnatural and less energy efficient rhythm. Similarly, Dal et al., (6) who compared self-selected walking speed between the two modes reported that young adults tended to walk faster overground which was more energy efficient and resulted in a more advantageous position regarding the U-shaped curve than the slower self-selected pace observed on a treadmill (4). It has also been suggested that adopting a slower walking speed may increase the relative intensity (23, 25, 37). Dal et al. (6) also suggested that slower self-selected treadmill walking speeds may be attributed to additional balance and coordination being required during treadmill walking, which may explain the higher energy costs observed (i.e. increased muscle force requirement) (4). However, 10 minutes of treadmill familiarisation has been suggested to reduce these additional energy requirements (6, 36). Although treadmill familiarisation was less than the recommended period of 10 minutes in the current study, all the girls regularly used the treadmill during physical education lessons and therefore this was not considered a likely contributor to the observed difference.

## Optimal walking speed and step rate

Interestingly during the moderately paced walking trial in the current study, walking speed was the same for both the treadmill and overground trials (approximately 3mph). This is consistent with the findings of Berryman et al. (4) who found that an optimal speed of approximately 3mph (2.98mph) was the same for both treadmill and overground in older adults. They suggested that this walking speed may be the best compromise regarding the ability to use the elastic energy and maintain stability. These findings also support the hypothesis that there is a preferred rhythmical human behaviour (15,16). Further studies which have aimed to establish step based recommendations with regard to moderate intensity walking have also indicated little difference in step rate at moderate intensity walking speeds between the two modes (14, 30). Rowe et al., (30) and Harrington et al., (14) compared and cross validated treadmill walking overground respectively and concluded that the replication of prior treadmill step rates to overground supports the use of treadmill step recommendations for practical situations. However, the focus of these studies was step rate associated intensity rather than the energy cost per se and despite this agreement in walking speed/step rate between the two modes, in the current study the oxygen cost per step was still significantly greater on the treadmill at step rates equivalent to the moderate walking speed. This illustrates that although 3 mph and 120 steps·min$^{-1}$ may be a comfortable and economical walking speed (optimal speed and step rate) for adolescent girls, the treadmill artificially elevates the energy cost per step. This indicates that the step rate/speed relationship is different on a treadmill and overground in adolescent girls, as has been previously demonstrated in adults (38) and further illustrates the problem with using the treadmill to infer step based recommendations.

## Implication for step based recommendations

While the intended application of any step based recommendation is overground walking in a real world setting, the treadmill is often utilised as a matter of convenience. From the current study it is clear that treadmill walking does not replicate walking overground under controlled conditions and therefore increased oxygen cost per step observed on the treadmill may lead to an underestimation of the step rate required to achieve moderate intensity activity in overground walking. It is also acknowledged that under such controlled conditions ecological validity is reduced (24). However, oxygen cost per step examined within the current study is a higher resolution than has previously been reported (1, 3,14, 24, 20, 34). While this may be useful for scientific research purposes, physical activity and allied health professional, to better understand the complex nature of the energy cost of walking, it may not be useful for general health recommendations per se. Further there is little known about the energy cost and step rate equivalence with regard to other overground walking conditions such as walking on other surfaces e.g. grass, gravel paths and pavement with curbs under free living conditions. Further research is required into natural and moderate intensity walking speed and step rates over such surfaces. This may be particularly important with regard to implementing step based recommendations and walking interventions.

## Strengths and Limitations

The current study had several strengths. It is the only study to compare the energy cost of treadmill and overground walking with regard to step rate ($steps \cdot min^{-1}$) and step rate associated intensity in youth. The energy cost of walking was assessed using indirect calorimetry (METS derived from oxygen uptake) during both the treadmill and overground walking trials. Therefore, MET values derived are ‘true’ MET values, rather than estimated. Resting metabolic rate was representative of 1 MET and therefore 3 MET is approximately moderate intensity. The mean resting energy expenditure of 5.4 $ml \cdot kg^{-1} \cdot min^{-1}$is also similar to values reported elsewhere (10, 13). Step rates have also been derived from real time direct observation rather than pedometer counts. However, it should be noted that video verification of the observed step count was not conducted and is considered to be a limitation of the study.  Further limitations of this study are that the results may not be generalisable or extend to other populations.

Furthermore, walking speeds were constant and not self-selected or randomised. Overground step rate was prescribed from treadmill step rate at the set speeds of 2.0, 3.0 and 4.0 mph. Despite these measures, some of the girls naturally adjusted to a self-selected speed overground. To overcome this limitation, it may have been more appropriate to allow the girls to walk at self-selected speeds overground, and subsequently match this speed to the treadmill. It is also acknowledged that the influence of different anthropometric indies on step-rate associated intensity previously reported (3, 17, 20) have not been reported within the current study and although these findings cannot be generalised to adolescent girls, within whom growth and maturation are prevalent, it is considered a limitation of the current study.

## Conclusion

The results of the current study suggest that at step rates representative of moderate to vigorous intensity activity (fast walking speed), the metabolic cost of treadmill walking is statistically different and not statistically equivalent to walking overground. Further when expressed as the high resolution oxygen cost per step, ( $\dot{V}O_2$ ml· step $^{-1}$) the current study suggests treadmill walking overestimates (statistically different from) and is not statistically equivalent to walking overground at moderate and fast walking speeds. Step count recommendations translated from treadmill walking may therefore underestimate the step rate required to promote health enhancing overground walking. Consequently, studies that aim to explore the step rate that corresponds to moderate to vigorous intensity activity should focus on overground walking, as this would generalise more accurately to real-life walking behaviour.

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**Table 1.** Physical characteristics

| **Variable** | **Mean±SD** | **Range** |
|---|---|---|
| Age (yrs) | 14.0±0.5 | 12.9-15.0 |
| Height (cm) | 160.73±5.80 | 150.30-178.20 |
| Weight (kg) | 52.52±10.27 | 37.00-75.00 |
| BMI | 20.27±3.57 | 15.92-29.07 |
| Resting $\dot{V}O_2$ (ml·kg$^{-1}$·min$^{-1}$) | 5.40±0.85 | 3.39-7.25 |

$\dot{V}O_2$= Oxygen uptake

**Table 2.** Dependent variables at each speed comparing treadmill with overground walking

| **Variable** | **Treadmill walking** | | | **Overground walking** | | |
|---|---|---|---|---|---|---|
| **Walking trial** | Slow | Moderate | Fast | Slow | Moderate | Fast |
| **Walking speed($m \cdot s^{-1}$)** | 0.89±0.0# | 1.34±0.0 | 1.78±0.0** | 1.12±0.16 | 1.36±0.15 | 1.59±0.17 |
| **Step Rate** | 100±7 | 120±6 | 133±6 | 100±6 | 120±5 | 133±7 |
| **$\dot{V}O_2$($ml \cdot kg^{-1} \cdot min^{-1}$)** | 13.72±1.50 | 16.27±1.52 | 21.85±2.16** | 13.90±2.04 | 16.01±2.17 | 17.95±2.77 |
| **METs** | 2.63±0.35 | 3.15±0.54 | 4.23±0.79** | 2.66±0.42 | 3.08±0.50 | 3.46±0.68 |
| **$\dot{V}O_2$ ($ml \cdot step^{-1}$)** | 7.34±1.30 | 7.23±1.44** | 8.46±1.45** | 7.25±1.38 | 6.80±1.22 | 7.00±1.19 |

$\dot{V}O_2$= Oxygen uptake; MET= metabolic equivalent.

**significantly higher than overground walking ($p < 0.01$), # significantly lower than overground walking ($p < 0.01$)

**Table 3.** Group level agreement of treadmill and overground response variables

| **Variable** | **Treadmill walking** | | | | | | **Overground walking** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Walking trial** | Slow | | Moderate | | Fast | | Slow | | Moderate | | Fast | |
| **$\dot{V}O_2$(ml·kg$^{-1}$·min$^{-1}$)** | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| **Equivalence region (10%)** | 12.34 | 15.09 | 14.64 | 17.89 | 19.66## | 24.03## | 12.51 | 15.29 | 14.40 | 17.61 | 16.15 | 19.74 |
| **95% CI mean difference** | 13.02 | 14.39 | 15.57 | 16.95 | 20.86 | 22.82 | 12.94 | 14.85 | 15.02 | 16.99 | 16.68 | 19.20 |
| **METs** | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| **Equivalence region (10%)** | 2.36 | 2.89 | 2.83 | 3.46 | 3.8## | 4.65## | 2.39 | 2.92 | 2.77 | 3.38 | 3.11 | 3.80 |
| **95% CI mean difference** | 2.47 | 2.78 | 2.90 | 3.39 | 3.87 | 4.59 | 2.46 | 2.85 | 2.84 | 3.31 | 3.15 | 3.76 |
| **$\dot{V}O_2$ (ml· step $^{-1}$)** | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| **Equivalence region (10%)** | 6.60 | 8.07 | 6.50## | 7.95## | 7.61## | 9.30## | 6.52 | 7.97 | 6.12 | 7.48 | 6.30 | 7.70 |
| **95% CI mean difference** | 6.35 | 7.30 | 7.52 | 8.60 | 6.12 | 7.21 | 6.24 | 7.28 | 6.35 | 7.42 | 6.24 | 7.25 |

$\dot{V}O_2$= Oxygen uptake; MET= metabolic equivalent.

## Not equivalent at 10% to Overground walking