Metabolic Cost of Weighted Vests During Standing Cycling

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Abstract

Whether cycling on the road or pedaling in a club cycle class, this mode of activity is done using both seated or standing positions. Previous research has examined the effect that cycling position exerts on physiologic parameters such as heart rate (HR), oxygen consumption (VO_2), or rating of perceived exertion (RPE) during exercise (1–3). This research was intended to simulate hill climbing, which is applicable to a majority of road cyclists. However, no prior research has examined the effect of wearing a weighted vest during stationary standing cycling. As well, no research has investigated the effect of extended bouts of stationary standing cycling (1, 2, 3 and 4 minutes) on metabolic parameters. The implications for this research may directly impact individuals engaged in fitness center stationary cycling classes, which have become very popular in recent years. A primary focus of many fitness club enthusiasts lies in cardiovascular health and concomitant weight reduction. As a result, the purpose of this study was to examine the metabolic cost of wearing weighted vests, as a percent of body weight (BW), during standing cycling. Twelve cycle-trained female subjects (age=40±8 yr) randomly performed four, 4-minute standing vest trials (No Vest, 5%BW, 10%BW, 15%BW) of cycling at 65% of peak power output (PPO). A seated 4-min trial at 65% PPO served as the control. VO_2, kilocalorie expenditure (Kcal) and HR were monitored continuously during each exercise bout using open circuit spirometry and telemetry. RPE was recorded at the end of each minute for each 4-min trial.

Results indicated that VO_2 was 8% higher in standing conditions as compared to the seated cycling position at the same cycling workload. Standing cycling at 65% PPO resulted in subjects exercising at 87 to 89% of their actual VO_2max, indicating the challenging nature of standing cycling (with or without wearing a weighted vest) as compared to seated cycling. Cycling at 65% PPO resulted in HR responses ranging from 91 to 94% of the subjects' actual heart rate max values, also confirming the challenging workload of standing cycling bouts. For each standing condition there was a significant increase in oxygen consumption between minute 1 and minute

2. This increase was a 67 to 76% increase in energy expenditure for all standing cycling conditions. Data from this investigation indicate that one of he most meaningful ways to increase kilocalorie expenditure during cycle training is to incorporate standing cycling bouts lasting 2 to 3 minutes within the cycle aerobic program. Interestingly, although standing weighted vest cycling demonstrates to be a higher intensity of exercise physiologically, cycle-trained female subjects in this study found this type of training to be 'somewhat hard' to 'hard' by their ratings of perceived exertion. This suggests that with trained female cycles, standing stationary cycling (with or without weighted vests) may be readily integrated into a cyele training program.

Methods and Procedures

We studied the oxygen consumption (VO_2), heart rate (HR), kilocalorie expenditure (Kcal) and ratings of perceived exertion (RPE) response to 4-minute standing cycling trials wearing weighted vests (Hyperwear®, Austin, TX). Vest weights were adjusted to each subject's body weight (BW). Twelve cycle-trained female subjects performed 4-minute standing bouts of cycling for four randomized standing conditions: No vest, 5%BW, 10%BW, and 15%BW. Cycling trials were completed at an intensity of 65% of cycling peak power output (PPO). A seated 65% PPO bout served as the control trial.

All female volunteers were recreationally trained in cycling activity including road cycling, cycle classes and recumbent/upright cycle ergometer training modalities. Subjects were recruited from fitness facilities and/or cycling clubs. Study inclusion criterion included self-reported engagement in cycle activities >150 minutes/week for a minimum of 8 consecutive weeks preceding enrollment in the study. Subjects were excluded if they reported any known cardiovascular, pulmonary or metabolic disease and/or if they were pregnant.

After completing the university informed consent, HIPAA form, and health history questionnaire, subjects were familiarized with the methods and procedures of the study. Each subject then voided her bladder and bowel and completed a urine pregnancy test, as pregnancy was an exclusion criterion of the study. Body weight (BW) in kg and height (HT) in cm were collected following standard laboratory methods. Next, subjects performed a 25 Watt/min ramp VO_2max protocol with the initial workload set at 50 Watts on a Lode Excalibur ergometer (Lode B.V., Groningen, the Netherlands). Subjects were encouraged to cycle at a revolutions-per-minute (RPM) they felt most comfortable during a bout of cycling exercise. During the final stages of the PPO test subjects were encouraged to stand in an effort to attain the highest PPO prior to exhaustion. If the cadence appeared awkward due to the electronic braking of the bike, clients were provided with recommendations to speed up or slow down to allow the electronic bike to better support their body weight. Following the PPO test, subjects quietly rested in a chair for 10 minutes to allow physiological parameters to return to near pre-exercise levels. Subjects then preformed a seated 4-minute (no vest) cycling trial at 65% PPO. This trial served as the control for this study. Finally, subjects were fitted (small, medium or large) with their vest and then scheduled for their second (and final) testing trial.

Subjects returned after 48 hours and no more than 10 days later for their second laboratory testing. At the second trial each subject initially voided bladder/bowel, put on a heart rate monitor, and changed into cycling attire. The cycle ergometer was set-up with the same handle bar, seat, and pedal settings as the first visit. Subjects completed a warm-up on the cycle ergometer for 4 minutes at 40% of PPO. Subjects then completed four, 4-minute standing (climbing position) cycling trials wearing a weighted vest adjusted to each subjects BW (No Vest, 5% BW, 10%BW, 15%BW). Trials were ordered in a randomized balanced Latin square design. Thus, with 12 subjects each trial condition was equally balanced in order with all other trials.

VO_2 and Kcal were measured continuously by expired gas analysis indirect calorimetry (ParvoMedics, Sandy, UT). HR was monitored continuously by telemetry (Polar^{TM}). RPE was taken at the end of each minute for every trial. Data from minutes 3 and 4 were averaged and used for the data analysis.

Statistics

All data was initially analyzed using a within factor repeated analysis of variance (ANOVA). Probability was set at $p \leq 0.05$. When significant differences were noted, post-hoc pair-wise comparisons were completed to determine where differences existed in exercise trials.

Results

Subject descriptive data are presented in Table 1. For their age (40±8.0 yrs) female subjects maximal aerobic capacity (44.88±5.79) places subjects in the ~83 percentile for their age group according to ACSM's fitness categories classification for actual maximal aerobic power testing (4). Subjects BMI (21.1 kg/m^2) is classified as normal according to ACSM standards.

Table 1. Subject Descriptive Statistics

Parameter	Value*
Age (yr)	40±8.0
Weight (kg)	57.33±5.33
Height (cm)	164.8±6.5
BMI (kg/m^2)	21.1±1.5
Max VO_2 (ml/kg/min)	44.88±5.79
Max VO_2 (L/min)	2.53±0.36
Max RER (VCO_2/VO_2)	1.24±0.07
Peak Power Output (Watts)	235±29
Max Heart Rate (b/min)	173±13
65% Peak Power Output (Watts)	152±18.67
Max RPE (6-20 unit scale)	18.5±1.8

*mean±standard deviation

VO_2 Results

VO_2 results comparing the five cycling conditions are shown in Figure 1. Each 4-min trial was completed at 65% PPO at the subject's preferred self-selected cycling cadence. Results clearly show a significant ($p < 0.05$) increase in oxygen consumption between all standing trials versus the seated control. VO_2 was 8% higher in standing conditions as compared to the traditional seated cycling position. No significant difference was seen between standing cycling (no vest) and wearing a 5%,BW 10%BW or 15%BW weighted vest. Standing cycling at 65% PPO resulted in subjects exercising at 87 to 89% of their actual VO_2max, indicating the challenging nature of standing cycling, with or without wearing a weighted vest.

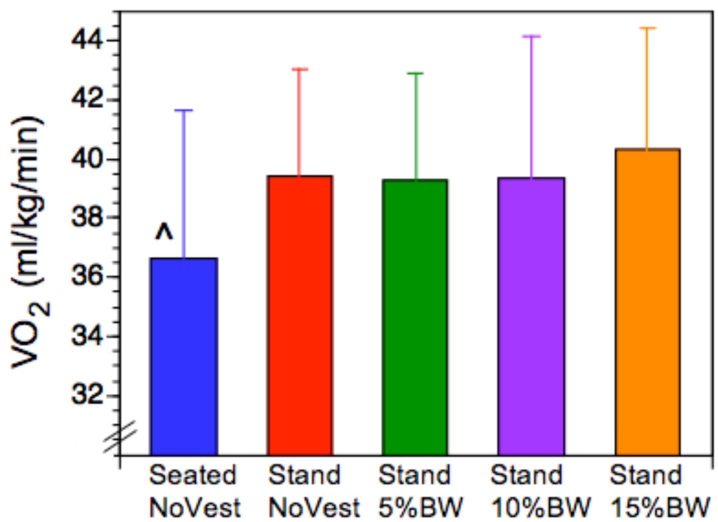

Figure 1. VO_2 Data for Five Trials
^Seated NoVest cycling significantly ($p < 0.05$) lower than all standing trials.

<u>Heart Rate Results</u>

HR results comparing the five cycling conditions are shown in Figure 2. Each 4-min trial was completed at 65% PPO at the subject's preferred self-selected cycling cadence. No significant difference was observed between the seated cycling and standing cycling and wearing a 5%BW, 10%BW or 15%BW adjusted weighted vest. This may most likely be attributable to the large standard deviations (ranging from 9 to 11 beats/min) of the subjects. Cycling at 65% PPO resulted in HR responses ranging from 91 to 94% of the subjects' actual HR max values.

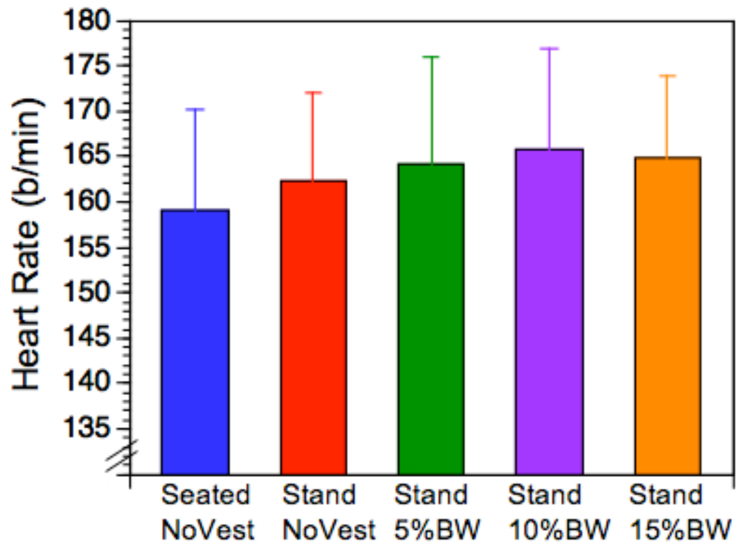

Figure 2. Heart Rate Data for Five Trials

<u>Kilocalorie Expenditure Results</u>

Kcal results comparing the five cycling conditions are shown in Figure 3. Results noticeably show a significant ($p < 0.05$) increase in energy expenditure with all standing trials versus the seated control. Kcal expenditure was 10% higher in all standing conditions as compared to the traditional seated cycling position. In addition, a significant ($p < 0.05$) difference was found between standing cycling with 15%BW as compared to standing cycling with no vest. Standing cycling increases the energy demands of cycling markedly.

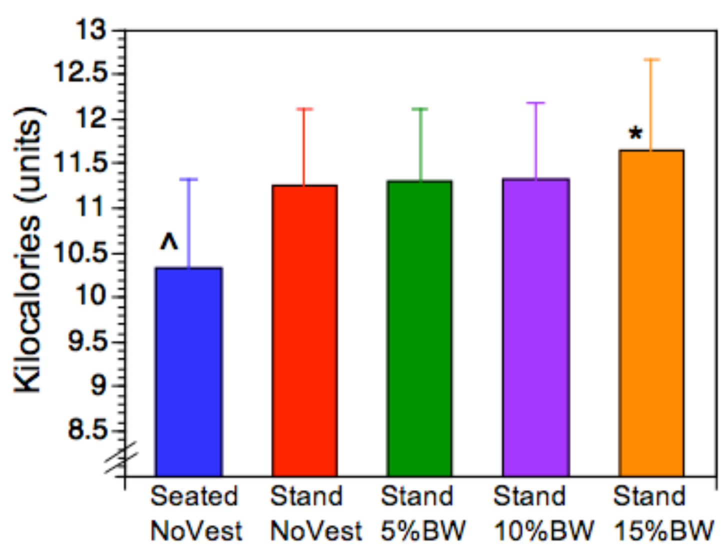

Figure 3. Kcal Data for Five Trials
^Seated NoVest cycling significantly ($p < 0.05$) lower than all standing trials.

*Standing 15%BW cycling significantly ($p < 0.05$) higher kcal then standing cycling with no vest.

RPE Results

RPE results comparisons of the five cycling conditions are shown in Figure 4. Perception of effort during standing cycling is mildly higher when wearing the heavier vests. Standing cycling with 10%BW and 15%BW vests had significantly ($p < 0.05$) higher perceived effort than seated cycling. Standing cycling wearing 10%BW and 15%BW vests were significantly ($p < 0.05$) higher perceived effort than standing cycling with no vest and standing cycling with a 5%BW weighted vest.

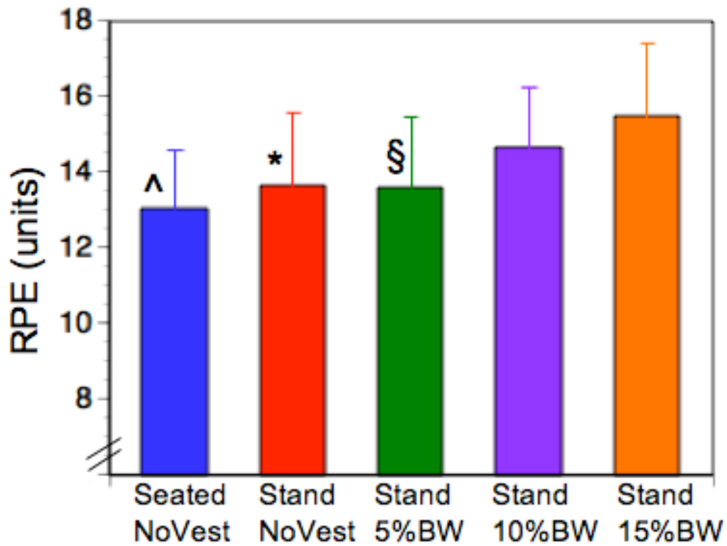

Figure 4. RPE Data for Five Trials
^Seated cycling significantly ($p < 0.05$) lower than standing 10%BW and 15%BW cycling
*Standing NoVest cycling significantly ($p < 0.05$) lower then standing 10%BW and 15%BW cycling
§Standing 5%BW cycling significantly ($p < 0.05$) lower then standing 10%BW and 15%BW cycling

VO_2 Between Minutes of 4-Minute Trials

A novel question of this investigation was whether there was a difference in oxygen consumption between minutes (i.e., between minute 1 and the other 3 minutes; between minute 2 and the other minutes; between minute 3 and the other minutes; between minute 4 and the other minutes) of the standing cycling trials. As can be seen with Figure 5, there was a significant increase in oxygen consumption between minute 1 and minute 2 of all standing trials. This energy expenditure increase was from 67 to 76% for all standing cycling conditions. There was also a modest increase ranging from 6 to 10% in oxygen consumption between minutes 2 and 3. Energy expenditure stabilized between minute 3 and 4 on all standing cycling conditions. This information provides program design suggestions for personal trainers and club cycle instructors desiring to optimize caloric expenditure utilizing research-driven methodology. Clearly, the inclusion of standing cycling bouts for 2 to 3 minutes during a cycling bout meaningfully increases energy expenditure. This increase in oxygen demand occurs during standing, with or without a weighted vest (up to 15%BW was used in this study). According to Tanaka et al (3), this energy expenditure increase is attributable to the increased muscle blood flow and/or involvement of a larger muscle mass with standing cycling.

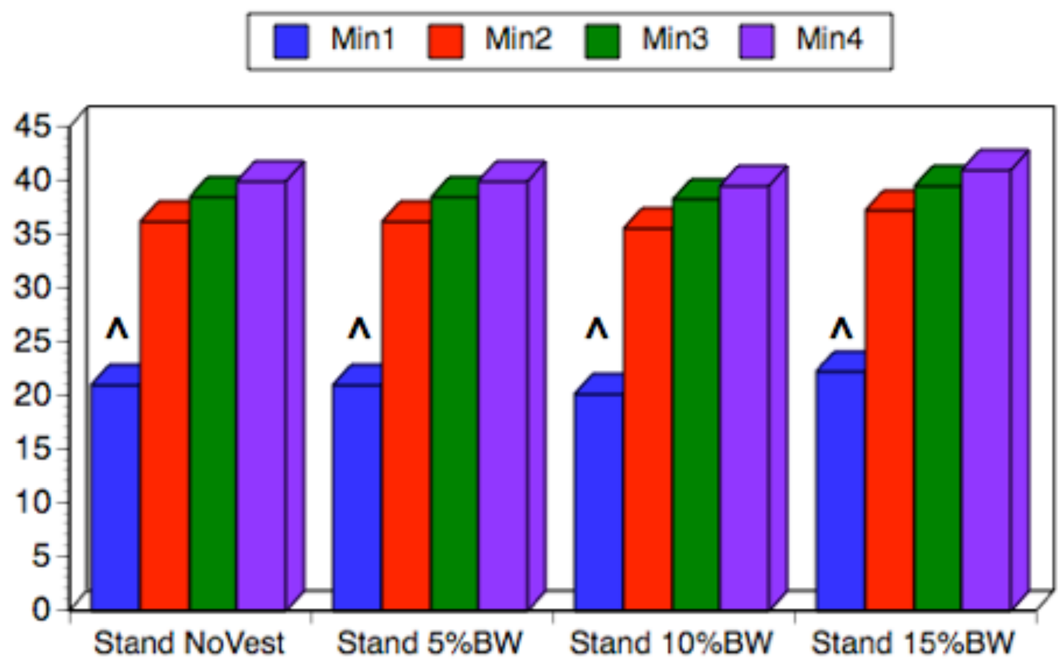

Figure 5. VO2 Minute Comparison within Each Standing Trial
^Minute 1 of each trial significantly ($p < 0.05$) lower than minutes 2, 3, and 4 for each standing cycling condition

CONCLUSIONS

It appears that standing cycling meets and may at times exceed the intensity guidelines (60% to <90% VO_2Reserve) of the American College of Sports Medicine (4) to maintain and/or improve cardiorespiratory fitness. All subjects standing cycling bouts averaged between 87 to 89% of their actual VO_2max and 91 to 94% of their actual HR max. Interestingly, subjects RPE assessments indicate that standing cycling with or without a weighted vest ranged from 'somewhat hard' to 'hard', yet their physiological parameters suggested they were training at a 'very hard' intensity. Results specify that VO_2 was 8% higher in standing conditions as compared to the seated cycling position at the same work. For each 4-minute standing condition bout there was a significant increase in oxygen consumption between minute 1 and minute 2. This increase was a 67 to 76% increase in oxygen consumption for all standing cycling conditions. Data from this investigation suggest that one of he most meaningful ways to increase kilocalorie expenditure to cycling exercise is to include stationary cycling bouts of 2 to 3 minutes (with or without weighted vests) during the cycling bouts. Comparatively, during standing exercise (with or without weighted vests) the subjects expended an average of 6 Kcals/min during the first minute, 10.5 Kcals the second minute, and 11.5 Kcals for the combined average of minutes 3 and 4. A significant ($p < 0.05$) difference in Kcal expenditure was found between standing cycling with 15%BW as compared to standing cycling with no vest. This suggests that a heavier weighted vest is needed to elicit higher energy expenditure outcomes. Lastly, the subjects' perceived their standing cycling, with and without weighted vests, as 'somewhat hard' to 'hard', perhaps suggesting that this kind of training may be readily implemented into cycle ergometer program designs with experienced cyclists.

References

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