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The Effects of Two Different Body Weight Support Harnesses on Oxygen Consumption and Heart Rate in Healthy Individuals

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THE EFFECTS OF TWO DIFFERENT BODY WEIGHT SUPPORT HARNESSES ON OXYGEN CONSUMPTION AND HEART RATE IN HEALTHY INDIVIDUALS

by

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The use of a body weight support hydraulic system can be beneficial for athletes with lower extremity injuries to help maintain cardiovascular fitness and provide athletes with the ability to advance lower extremity injuries to full weight bearing earlier than without a body weight support harness. However, body weight support harnesses can be a limiting factor due to rubbing or riding up when an injured athlete is attempting to maintain their current level of cardiovascular fitness. Discomfort is experienced with the use of many harnesses in the form of rubbing, tightness, and sliding up the torso. Two different body weight support harnesses were tested to determine oxygen consumption (VO_2), heart rate (HR), and Rating of Perceived Exertion (RPE) during two, 30-minute submaximal treadmill exercise session with 30% of the body weight supported. Ten volunteer subjects performed 30 minutes of submaximal exercise using the Pneu-vest harness™ with and without the cheek strap. A two-way analysis of variance with repeated measures test was used to analyze the results. The results showed no significant difference in VO_2, HR, or RPE ($P < .05$), between the two trials. All subjects were able to complete all the testing trials indicating minimal discomfort from the harnesses.

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INRODUCTION

Body weight support (BWS) harnesses are devices used to aid athletic trainers, physical therapists, and strength and conditioning coaches in the rehabilitation and conditioning of active individuals.[1-7] Body weight support harnesses can be used in conjunction with a treadmill and a hydraulic system which allows a rehabilitation specialist to remove body weight from the patient for pain free walking or running. Different manufacturers, specifically Pneumex™ have designed hydraulic systems and BWS harnesses that attach to the patient's torso via velcro straps and connects to the hydraulic system above the subject's head.[8] Pneumex™ has designed the Pneu-vest™ BWS harness for physically active individuals that fits small, medium, and large men and women and is used in conjunction with the Single-Pneu-Weight™ hydraulic system.[8] This harness can be used with or without the cheek strap that is intended to hold the harness in place and prevent it from riding up the patient's torso.

The use of BWS harnesses with treadmills is helpful in allowing physically active individuals to continue to stay active, when they may not be able to otherwise, and rehabilitate lower extremity injuries without creating further harm.[1-7, 9,10] Successful athletes use aerobic conditioning as part of a physical conditioning program.[9,10] Athletes need to train specifically for their sport, but all athletes can gain cardiovascular fitness using the long, slow distance training method.[9-11] The use of the BWS harnesses and treadmills has been beneficial for cardiovascular maintenance with injured athletes as well as healthy athletes.[1-4,7] Body weight support harnesses can be used with a variety of lower extremity injuries in the foot, ankle, knee, hip, pelvis, and lumbar spine.[9,11]

Athletic trainers need to incorporate cardiovascular training into rehabilitation protocols for lower extremity injuries.[9,10] The nature of injuries to active individuals vary from situation to situation and a BWS harness gives rehabilitation specialists the flexibility to determine the proper amount of BWS needed to prevent further harm to the athlete while continuing to maintain a current level of cardiovascular fitness at a high level to be able to transition back into competition.[10,11] The primary concern of rehabilitation specialist, who is attempting to rehabilitate an injured athlete, is not only to efficiently and effectively return athletes to their respective sports, but also to create no further harm that may occur with full weight bearing activities.[6,9,11-13] Body weight support harnesses have also allowed stroke patients to regain and improve their walking ability by allowing them to improve an antalgic gait with decreased body weight.[13]

Walking is one of the most desired goals for people with spinal cord injuries.[12] A BWS harness has the capability of allowing a patient with a spinal cord injury to walk, and can also be effective for a healthy athlete with a lower extremity injury. Research has also shown that patients with spinal cord injuries may need up to 40% BWS for proper walking mechanics to be achieved.[6,12] However, it is important to use the smallest BWS percentage possible with attempting to rehabilitate a patient.[6,9,10] Progressive resistance exercise is important when training an athlete, so the more body weight the athlete or patient can handle, the more functional the activity.[10] This follows Wolff's Law that says, form follows function.[9] As stress is applied to the injured lower extremity in rehabilitation, the body adapts to allow for further stress to be applied without creating damage.[9-11]

One group of researchers observed normal gait of the 15 subjects at both 30 and 50% BWS but gait was altered at 70% BWS during eight walking speed trials.[5] Previous research has shown that submaximal exercise testing appears to have greater applicability to physical therapists in their role as clinical exercise specialists. This is useful because of the importance of continued, submaximal cardiovascular maintenance while an athlete is injured. Maximal exercise should not be used during the same rehabilitation stage when full weight bearing is contraindicated.[9,14] In the assessment of several submaximal exercise testing protocols, it was determined that heart rate, blood pressure, rating of perceived exertion, and pain helped the researchers gather valid and reliable results.[14] A series of studies determined that different BWS percentages effect gait and lower extremity function. This research was designed for use with patients with neurological impairments, such as spinal cord injuries or stroke patients, but healthy subjects were tested. The results of this research showed that 30 % BWS is most effective for improving cardiovascular fitness after a lower extremity injury.[1-4] Prior to rehabilitation, proper gait must be regained and maintained to prevent further injury.[9,10] Improving gait for athletes with lower extremity injuries may be the first step in the recovery process, and is necessary for proper mechanics during continued endurance training.[9,10] A BWS percentage higher than that may be supportive enough for training neurologically impaired patients.[1-7,12,13] In the field of athletic training, most injuries are neuromuscular or orthopedic in nature, and thus, more than 30% BWS is often times not necessary, as most athletic injuries do not lead to neurological impairments.[9,10]

A common complaint in the use of the harness is that it causes discomfort, specifically during exertional cardiovascular training. Discomfort includes skin irritation from friction of the harness rubbing on the skin, tightness around the torso, difficulty breathing due to the tightness of the harness, and the harness moving up the torso during the conditioning period. These limitations reduce the length of time athletes are able to continue their treadmill workout.[1,2,5,6] It is important to investigate various types of harness supports to decrease or eliminate limitations. Body weight support harnesses should not be a limiting factor for an athlete to continue cardiovascular training and it is important to understand the physiological effects of the different BWS harnesses on the individuals. The more comfortable the harness, the less effect the harness may have on oxygen consumption (VO_2), heart rate (HR), and rating of perceived exertion (RPE) from the Borg scale, and the less the harness will alter gait or running mechanics. The less effect a BWS harness has on an individuals comfort level, the better able the individual will be able to continue with a physical conditioning program.[1,9-11] The purpose of this study is to determine how two different BWS harnesses effect VO_2, HR, RPE (Borg Scale), and assessment of comfort during a 30-minute submaximal treadmill exercise session with 30% of the body weight supported.

METHODS

Subjects and Design

Ten volunteer subjects, five males and five females, between the ages of 20 and 26 years old were recruited by personal contact on the campus of Western Michigan University. The physical characteristics of the subject were height 172 ± 13 cm (range 157-185 cm) and weight 72 ± 17 kg (range 59-100 kg). The subjects were screened for cardiovascular disease, musculoskeletal abnormalities, or pulmonary disease that would preclude submaximal treadmill exercise using the Physical Activity Readiness Questionnaire (PAR-Q).[15] Potential subjects were asked to complete the PAR-Q that was developed to identify individuals for whom physical activity may be contraindicated. An informed consent, approved by the Western Michigan University Human Subject Institutional Review Board, was obtained from each subject. All testing took place in the Health, Physical Education, and Recreation Department in the Exercise Physiology Laboratory at Western Michigan University. Date of birth was also gathered from each subject prior to their first testing trail in a familiarization session where each subject was then fitted for the properly sized Pneu-vest™ harness (small, medium, and large), based on waist circumference and according to the manufacturer guidelines.[8] Subjects were instructed to not eat two hours prior to their testing session, drink caffeinated beverages six hours prior to their testing session, and perform exertional exercise 12 hours prior to their testing session. Subjects were then given an opportunity to practice running on the treadmill to determine speeds for jogging during the two trial periods. A two-way

ANOVA with repeated measures on both factors test was used. Subjects performed two separate submaximal exercise testing protocols with a body weight support harness and the use of a treadmill.

Each of the ten subjects performed two separate trials, performed on different days with at least 48 hours separating each trial. Half of the subjects were tested in the harness with the cheek strap in place for their first trial and without the cheek strap for the second trial. The other five subjects completed their trials in the reverse order. The conditions included: 1) Harness with the Pneu-Vest™ cheek strap in place, with 30% of body weight supported and 2) Harness without the Pneu-vest™ cheek strap in place with 30% of body weight supported. The second condition was the different speeds of the treadmill. The speeds included: 1) three mph walk for five minutes, 2) a slow comfortable jog for ten minutes, 3) an increase in the treadmill speed by 0.5 mph for ten minutes, and 4) three mph walk for five minutes, respectively. During a familiarization session, subjects signed the consent form, were weighed and measured for height. All subjects were also given the opportunity to practice running on the treadmill to determine speeds to be used during the testing sessions.

Procedures

Subjects were weighed (in kilograms) before both testing sessions to determine 30% of their body weight. Before set-up, subjects were instructed on the RPE scale. All subjects were told to use the lowest number (6) as a feeling of resting comfortably on a couch and the highest number (20) as the most difficult exercise imaginable. Subjects were asked to give an accurate assessment of the whole body feeling, and not to target specific areas of discomfort. A Cardiosport heart rate monitor (Deer Park, NY) was applied to the bare chest of each subject to monitor HR each minute. Then the harness with or without the cheek strap was applied to the subject according to manufacturer guidelines. The harness fit snuggly around the subject's torso and held in place with two velcro straps and adjustments were made to tighten the harness for comfort. The cheek strap was then clipped to the bottom-front section of the harness and wrapped around under the subject's gluteals and tightened for comfort. This research removed 30% BWS during the testing sessions. This percentage will allow an athlete to maintain proper walking and running mechanics and thus decrease the possibility for further injury to the lower extremity.[1-4,7] Each subjects' body weight was decreased by 30% and was supported using the Single-Pneu-Weight™ Hydraulic System (City, 2002). All testing was done on a Quinton Treadmill (model #Q65, Cortland, New York).

Once the heart rate monitor and harness with 30% BWS were in place and properly adjusted, the headgear, noseclip and mouthpiece were placed on the subject for oxygen consumption readings. The metabolic measurement cart (Vmax 229LV, Sensor Medics, Yorba Linca, CA) was calibrated, according to manufacturer guidelines, between each subject and trial for accuracy and ventilation and the percent of oxygen in the expired air was collected continuously and averaged every minute. Subjects were then asked to straddle the treadmill during which time the belt was started and adjusted to the first walking speed of three miles per hour. For balance, subjects were instructed to hold the side panels of the Pneu-weight™ hydraulic system and step onto the treadmill and begin the five-minute walking period. After the warm-up period, the treadmill speed was increased to the pre-determined jogging speed from the familiarization session. This jogging period lasted for ten minutes with an average speed of 5.30 ± 0.04 miles per hour. After this period of time, the treadmill speed was increased again to a faster jogging speed, also pre-determined for ten more minutes at an average of 5.90 ± 0.49 miles per hour. Immediately following both ten minute jogging periods, the treadmill speed was decreased to three miles per hour for the final five-minute cool-down walk. All speeds were recorded and used for the second testing session.

Oxygen Consumption, heart rate, and rating of perceived exertion were measured throughout the testing sessions. The 4th and 5th, 13th and 14th, 23rd and 24th, and 29th and 30th minutes were averaged for the four time periods measured for VO_2. The 13th and 14th, 23rd and 24th, and 29th and 30th minutes were averaged for the three time periods measured for HR and RPE.

After each testing session, the treadmill was stopped, the subject was unhooked from the BWS harness, and the head gear, mouth piece, and noseclip were removed. All equipment was cleaned for use on the next subject. Prior to each subject leaving, their HR had to return to the resting HR taken prior to the testing session. The VO_2 data was printed and added to the HR and RPE data and stored in a locked file cabinet until the next session, or until analyzed.

Data Analysis

The VO_2, HR, and RPE values of the harness with and without the cheek strap in association with speed values were recorded and a two-way ANOVA with repeated measures on both factors test was used to determine the differences between the two testing trials. An alpha level $P < 0.05$ level of significance was used. The data that was collected then analyzed with descriptive statistics by Statistical Package for the Social Sciences (SPSS 11.5, Chicago, IL, 2002).

RESULTS

Oxygen Consumption (VO_2)

The responses for VO_2 with and without strap usage during the 30 minute exercise session are listed in Table 1. Overall, there was no effect of strap usage on the VO_2 responses during the treadmill exercise (Strap =20.22 ± 2.21, No Strap = 20.28 ± 2.13; $P < 0.05$). As expected, there was a significant main effect for speed in that VO_2 increased as treadmill speed increased (Table 2). Lastly, the condition-by-speed interaction was not significant indicating that the response in VO_2 changed similarly with speed regardless of whether or not the strap was used.

Heart Rate (HR)

The responses for HR with and without strap usage during the 30 minute exercise session are listed in Table 1. Overall, there was no effect of strap usage on the HR responses during the treadmill exercise (Strap = 153 ± 15, No Strap = 155 ± 14; $P < 0.05$). As expected, there was a significant main effect for speed in that HR increased as treadmill speed increased (Table 2). Lastly, the condition-by-speed interaction was not significant indicating that the response in HR changed similarly with speed regardless of whether or not the strap was used.

Rating of Perceived Exertion (RPE)

The responses for RPE with and without strap usage during the 30 minute exercise session are listed in Table 1. Overall, there was no effect of strap usage on the RPE responses during the treadmill exercise (Strap = 13 ± 2, No Strap = 13 ± 2; P <

0.05). As expected, there was a significant main effect for speed in that RPE increased as treadmill speed increased (Table 2). Lastly, the condition-by-speed interaction was not significant indicating that the response in RPE changed similarly with speed regardless of whether or not the strap was used.

All subjects successfully completed both trials in this research without complication. Also, no subject complained of rubbing, or extreme discomfort caused by the harness. Three male subjects noted a difference in the feel of the harnesses. All three subjects felt an increased comfort with the use of the cheek strap in that is disallowed the harness to ride up the torso. The other seven subjects did not find any significant difference in the use of the harnesses with or without the cheek strap. Three of the ten subjects lost the effect of the cheek strap as it rode up and over the buttock during the trial period. This did not cause discomfort for these subjects. One subject complained of tightness around the torso during the first trial. Eight of the ten subjects felt comfort when the harness was applied and felt that is created stability in the lumbar spine.

DISCUSSION

The purpose of this study was to determine how two different BWS harnesses effect VO_2, HR, RPE, and assessment of comfort during a 30-minute submaximal treadmill workout with 30% of the body weight supported. As the treadmill speed increases, submaximal VO_2, HR, and RPE also increase. This relationship is not affected by the use of a BWS harness with or without the cheek strap with 30 % of the body weight decreased. The relationship of the harness to the speed of the treadmill was not significant. The relationship of the harness with and without the cheek strap on VO_2, HR, and RPE also showed no significant difference. All of the subjects in this study were able to successfully completed all of the testing sessions. The BWS harness was not too tight, did not rub, ride up the torso, or create difficulty in breathing during the testing sessions. Three of 10 subjects felt an improvement with the cheek strap, specifically, they felt is was more secure and held the harness in place better than without the cheek strap. All the other subjects did not notice a significant difference between the harness with or without the cheek strap.

During the two trials, four of the ten subjects experienced high VO_2 values, near a VO_2 maximal test based on the RQ values collected from the metabolic measurement cart. Each of these subjects were able to continue all of the exercise sessions due to a decrease in body weight by 30%. Without the BWS, these subjects may have quit the exercise because if the harness is comfortable and 30% of the body weight is supported, the subject is doing less work than running on a treadmill without a BWS harness. An ability to continue a workout may be subjective, but when a patient's body weight is supported, it can be assumed that the more BWS, the less work an individual must perform in a 30 minute exercise session.

This harness helps to remove body weight, but is not restricting or uncomfortable enough to change the physiological values of the subjects. According to research, 30% BWS does not effect the gait of a healthy subject, thus, if gait is not effected, neither is the VO_2, HR, or RPE values based on this factor alone.[1-4] While gait was not analyzed in this research, this harness did not have a significant effect on gait because it did not interfere with the lower extremity. When body weight is decreased, the harness is comfortable, and gait is not effected, all physiologic values should be lowered. Since these two different harnesses have no difference in their effect on VO_2, HR, and RPE, the research specialist can focus on patient comfort without consideration on physiological effects. This is also of great benefit for research specialists as comfort is generally the limiting factor for training programs. The more options a research specialist has, the more effective they can be in increasing and maintaining cardiovascular endurance.

The Cardiosport heart rate monitors used in this study created difficulty for two female subjects. During the exercise session, the heart rate monitor lost connection and was not able to read an accurate HR. This did not effect the data gathered or the results of the study. Another problem encountered in this research was the cheek strap riding up over the buttock of three of the ten subjects. This eliminated the ability of the cheek strap to hold the harness down and work effectively. The cheek strap did not stay in place, possibly due to the subject's body type, the fabric of shorts the subject was wearing, or due to the gait of the subject. When the cheek strap did not work effectively, the subject tended to have a mesomorphic body type. Another subject that had the cheek strap ride up over the gluteals was wearing nylon shorts. The third reason for the cheek strap riding up was possibly due to a running gait with excessive hip movement. The cheek strap may need some modifications for increased effectiveness for the use with all patients of all body types. When fitted properly to the subject, the cheek strap did have a positive effect for three of the subjects.

The harness showed no difference regardless of the gender of the subject. Both males and females found the harness to be comfortable and was not a limiting factor in being able to continue during the exercise sessions. Gender difference on physiological values was not analyzed in this study. However, four of the five females felt the BWS harness was very comfortable compared to all five male subjects that felt the BWS harness was very comfortable. The one female however, did not find discomfort with the harness.

Research has shown a positive effect of BWS harnesses with neurologically impaired patients and athletes with lower extremity injuries.[1-7,9-11] Most of the research done on BWS harnesses is used on neurologically impaired patients.[1-4,7] However, the use of the results of this research on patients with neurological impairments would not be appropriate. Research on patients with neurologically impairments is beyond the scope of this research. This study was designed to benefit research specialists that work with active individuals with lower extremity injuries that will be able to return to their respective sport without complication.

More research could be conducted on the effects of the BWS harness on collegiate and elite athletes and maintaining or improving cardiovascular endurance. A VO_2 max test may be necessary to collect prior to testing sessions to have subjects perform the exercise at a certain percent of the max $\dot{V}O_2$. This may be a more consistent measure than having all subject exercise at a "comfortable", submaximal pace. Further research should also investigate extremely different BWS harnesses. Many different companies make many different BWS harnesses that could be investigated. This research would benefit not only rehabilitation specialists, but also the manufacturers to help improve BWS harnesses to be as comfortable as possible.

The effects of decreasing body weight for musculoskeletal abnormalities are evident, but more research is necessary to demonstrate physiological effects, specifically on gait. Several researchers have investigated appropriate amounts of BWS without effecting gait.[1-7,12] This is helpful for rehabilitation specialists, but all patients and injuries are different, and need different amounts of BWS. Athletes that will be returning to competition, need to use Wolff's Law and the principle of specific adaptation to imposed demands for a safe and efficient return to competition.[9,10] So, when using a BWS harness, only the amount of BWS that should be removed is just enough to eliminate pain to the lower extremity during walking or running on a treadmill. More research should be done on specifically, how much BWS is too much for elite athletes to continue to maintain proper gait and cardiovascular fitness.

Rehabilitation specialists would benefit from further research on the ability of BWS harness to maintain or improve cardiovascular fitness compared to other forms of rehabilitation, specifically aquatic training. Questions that need to be answered is the benefits of using a BWS harness over aquatic therapy due to cost, stage of rehabilitation, or patient preference.

CONCLUSION

In conclusion, BWS harnesses are effective tools in rehabilitation settings. The Pneu-Vest^{TM} harness is an effective harness with or without the cheek strap based on comfort. The Pneu-Vest^{TM} had no effect on VO_2, HR, and RPE values between trials which allows rehabilitation specialists to focus on comfort level of the patient without sacrificing the physiological effects. All subjects found comfort with this harness.

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Centennial
1903-2003 Celebration

Date: February 24, 2004

To: Donna Ritenour, Principal Investigator
Sara Koski, Student Investigator for thesis

From: Mary Lagerwey, Ph.D., Chair Mary Lagerwey

Re: HSIRB Project Number: 03-11-09

This letter will serve as confirmation that your research project entitled "Effects of Two Different Body Weight Support Harnesses on Oxygen Consumption and Heart Rate in Healthy Individuals" has been **approved** under the **full** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: November 19, 2004

Walwood Hall, Kalamazoo, MI 49008-5456

REFERENCES

1. MacKay-Lyons, M., Makrides, L., Speth, S. (2001). Effect of 15% body weight support on exercise capacity of adults without impairments. *Physical Therapy,* 81, 1790-1800.

2. Hesse, S., Helm, B., Krajnik, J. et al. (1997). Treadmill training with partial body weight support: Influence of body weight release on the gait of hemiparetic patients. *Journal of Neurological Rehabilitation,* 11, 15-20.

3. Hesse, S., Konrad, M., Uhlenbrock, D. (1999). Treadmill walking with partial body weight support versus floor walking in hemiparetic subjects. *Physical Medicine Rehabilitation,* 80, 421-7.

4. Hesse, S., Uhlenbrock, D. (2000). A mechanized gait trainer for restoration of gait. *Journal of Rehabilitation Research & Development,* 37, 701-8.

5. Finch, L., Barbeau, H., Arsenault, B. (1991). Influence of body weight support on normal human gait: development of a gait retraining strategy. *Physical Therapy,* 71, 842-56.

6. Wilson, M., Qureshy, H, Holmes, E., Et al. (2000). Equipment specifications for supported treadmill ambulation training. *Journal of Rehabilitation, Research, & Development,* 37, 415-422.

7. Da Cunha Filho, I., Lim, P., Qureshy, H., Henson, H., Et al. (2001). A comparison of regular rehabilitation and regular rehabilitation with supported

treadmill ambulation training for acute stroke patients. *Journal of Rehabilitation Research & Development,* 38, 245-55.

8. Pneu-Vest™ Instructions. (1998). Pneumex, Incorporated. www.pneumex.com.
9. Prentice, W. (2003). Arnheim's Principles of Athletic Training, Eleventh Edition. McGraw Hill, Burr Ridge, IL.
10. Baechle, T., Earle, R. (2000). Essentials of Strength Training and Conditioning, 2nd Edition. Human Kinetics, Champaign, IL.
11. McArdle, W., Katch, F., Katch, V. (1996). Exercise Physiology: Energy, Nutrition and Human Performance. Williams & Wilkins, Baltimore, MD.
12. Field-Fote, E. (2000). Spinal cord control of movement: Implications for locomotor rehabilitation following spinal cord injury. *Physical Therapy Association,* 80, 477-84.
13. Laufer, Y., Dickstein, R., Chefez, Y., Marcovitz, E. (2001). The effect of treadmill training on the ambulation of stroke survivors in the early stages of rehabilitation: A random study. *Journal of Rehabilitation Research,*38, 69-78.
14. Noonan, V., Dean, E. (2000). Submaximal exercise testing: Clinical application and interpretation. *Physical Therapy,* 80, 782-807.
15. Chishom, D., Collis, M., Kulak, L., et al (1975). Physical activity readiness. *Britain College of Medicine Journal,* 17, 375-8.

Table 1. VO_2 response (mL/kg/min) with and without strap usage during the 30 minute exercise session (Mean ± SD).

	Strap	No strap
VO_2 (mL/kg/min)		
Walk 1	10.50 ± 0.81	10.45 ± 0.74
Jog 1	28.03 ± 3.19	27.92 ± 3.16
Jog 2	30.87 ± 3.59	31.36 ± 3.64
Walk 2	11.49 ± 1.26	11.39 ± 0.97
Heart Rate (BPM)		
Jog 1	161 ± 16	162 ± 16
Jog 2	174 ± 15	175 ± 13
Walk 2	125 ± 13	128 ± 12
RPE (Borg 6-20)		
Jog 1	13 ± 2	13 ± 1
Jog 2	15 ± 2	15 ± 2
Walk 2	9 ± 1	10 ± 1

Table 2. Main effect for speed for VO_2, HR, and RPE

Variable/Speed	Walk 1	Jog 1	Jog 2	Walk 2
VO_2 (mL/kg/min)	10.46 ± 1.18	27.97 ± 3.17	31.11 ± 3.61	11.44 ± 1.12
HR (BPM)		161 ± 16	174 ± 14	126 ± 12
RPE (Borg 6-20)		13 ± 1	15 ± 2	10 ± 1