PHYSIOLOGICAL RESPONSES OF HEALTHY ADULTS TO WALKING WITH A POWERBELT

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ABSTRACT

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The purpose of this study was to provide descriptive data on the physiological responses to walking at a self-selected pace with and without a Powerbelt. In random order, ten male (age = 22 ± 0.9 yr, ht = 178 ± 5.8 cm, wt = 77 ± 11.1 kg) and ten female (age = 24 ± 6.0 yr, ht = 168 ± 6.1 cm, wt = 64 ± 10.5 kg) volunteers walked at a self-selected pace for 30 minutes unaided, with the Powerbelt base unit, and with the Powerbelt plus Power Pak1. Variables measured were oxygen consumption (VO_2) using open circuit spirometry, heart rate (HR), and rating of perceived exertion (RPE). When compared to unaided walking, the results showed walking with the Powerbelt base unit yielded significantly higher VO_2 (15.6 ± 2.25 vs 19.3 ± 2.20 $ml \cdot kg^{-1} \cdot min^{-1}$), HR (101 ± 8.2 vs 117 ± 13.9 bpm), and RPE (117 ± 13.9 vs 10 ± 1.4) responses. Walking with the Powerbelt plus Power Pak 1 yielded significantly higher VO_2 (20.8 ± 2.38 $ml \cdot kg^{-1} \cdot min^{-1}$), HR (125 ± 16.0 bpm), and RPE (12 ± 1.1) responses when compared to both unaided walking and walking with the Powerbelt base unit. The average caloric expenditure walking unaided was 5.4 ± 1.22 kcal/min, walking with the Powerbelt was 6.7 ± 1.43 kcal/min, and walking with Power Pak 1 was 7.2 ± 1.41 kcal/min. The results of this study indicate that walking with a Powerbelt with only the base unit or with Power Pak 1 provides an increased intensity over unaided walking, which may result in additional improvements during walking exercise.

COLLEGE OF HEALTH, PHYSICAL EDUCATION, AND RECREATION

UNIVERSITY OF WISCONSIN – LA CROSSE

THESIS FINAL ORAL DEFENSE FORM

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Master of Science in Adult Fitness/Cardiac Rehabilitation

The candidate has successfully completed the thesis final oral defense.

Thesis Committee Chairperson Signature — Date: 6/29/00

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Thesis Committee Member Signature — Date: 6/29/00

This thesis is approved by the College of Health, Physical Education, and Recreation.

Associate Dean, College of Health, Physical Education, and Recreation — Date: 11/16/00

Director of University Graduate Studies — Date: 11/17/00

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INTRODUCTION

The benefits of physical activity are well established, and studies continue to support the importance of exercise for maintaining health and overall well-being. According to the 1996 Surgeon General's Report on Physical Activity and Health and the American College of Sports Medicine (ACSM), physical activity lowers the risk of developing non-insulin dependent diabetes mellitus; helps control weight; contributes to the development and maintenance of healthier muscles, joints, and bones; and reduces the risk of developing or dying from cardiorespiratory disease and colon cancer (2,13). The ACSM also states that exercise may boost feelings of self-confidence, enhance feelings of well-being, and help alleviate anxiety and depression (2).

While the importance of exercise is evident, the best mode of exercise is constantly being questioned. Most contemporary data indicate that it is not the kind of exercise, but rather the regularity of exercise that is important. Blair et al. have shown that as little as 30 minutes of moderately vigorous physical activity will elicit health-related benefits, regardless of modality (4). To maintain and develop cardiorespiratory fitness and body composition in the healthy adult, the ACSM recommends performing 20-60 minutes of continuous or intermittent aerobic activity 3-5 days per week at 50-85% of VO_{2max} or 60-90% of maximal heart rate (2).

For most people, walking may be the best form of exercise. Walking is simple, inexpensive, and can be done almost anywhere throughout the year. Walking is also less likely to result in injuries, especially when compared to running (8). For the majority of

healthy people, unaided walking is an ideal workout to reach heart rate and metabolic targets. Difficulties can occur, however, with people who are either too fit to reach a training zone during unaided walking, or with those who can not reach a high enough intensity level due to orthopedic or biomechanical limitations (11). For these people, and for those who simply wish to add greater intensity to a walking workout, there are many different products that can be used to increase the intensity of walking. These products include ankle weights, weighted vests, hand and wrist weights, walking poles, and a newer device, the Powerbelt. In various studies all of these adjuncts have been tested, and while all methods were shown to increase heart rate, oxygen consumption, MET's and caloric expenditure, the Powerbelt was shown to have the greatest increase in all of the above areas. In a study done by Zedaker, Naser, and Porcari (16), it was found that when subjects walked with the different resistance settings of the Powerbelt the heart rate ranged from 27-44 beats per minute (bpm) higher and energy cost ranged from 42-64% greater than with unaided walking. Due to the experimental design of this study, however, there has been some criticism. The subjects only walked for three minutes at each resistance level with a three minute break between each exercise bout. Because the increases seen were so large, detractors argue that the increased intensity could not be maintained for a full 30 minute workout. Considering the importance of understanding what physiological changes could be expected of an exerciser using the Powerbelt under more representative usage conditions, the purpose of this study was to analyze the physiological responses, specifically VO_2, heart rate, caloric expenditure, and subjective

ratings of perceived exertion (RPE), from using the Powerbelt for an extended period of time.

METHODS

Subjects Ten apparently healthy male and ten apparently healthy female volunteers were recruited to participate in this study. All subjects were required to be at least moderately active, defined as exercising continuously for at least 20-60 minutes per day, three days per week (2). All subjects signed a written informed consent (see Appendix A) approved by the University of Wisconsin–La Crosse Institutional Review Board prior to the beginning of the study.

Powerbelt Orientation Prior to testing, each subject was given instructions regarding Powerbelt usage. Each subject then completed two practice sessions. During one practice session the subjects practiced walking on the treadmill and selected a pace which they would feel comfortable maintaining for 30 minutes. During the second practice session, each subject was allowed to practice on the treadmill using the Powerbelt base unit and Power Pak 1. Subjects were instructed to bring their fists to eye-level while using the Powerbelt, and to swing the arms in a natural manner.

Testing Protocol Each subject performed three testing sessions at least 24 hours apart, and were asked not to engage in strenuous exercise on the days of testing. All subjects were required to complete three workloads, consisting of unaided walking, walking using the Powerbelt base unit, and walking using the Powerbelt with Power Pak 1. All three workloads were conducted at the same treadmill speed, which had been individually determined during the practice sessions. Power Pak 2 and 3 were not tested, as a

previous study had shown that these intensities may be too difficult for most people to sustain for thirty minutes (16). Each exercise session lasted 30 minutes, and oxygen consumption (VO_2) and caloric expenditure (Kcals) were measured throughout each session using open circuit spirometry. Heart rate was also measured and recorded every minute using radiotelemetry. RPE was recorded every five minutes using the Borg 6-20 scale (see Appendix B) (5). The workloads were randomly ordered, and all subjects completed a five-minute warm up and cool down.

Statistics Basic descriptive statistics were used to summarize the subject's physical variables, as well as the physiological responses to each exercise session. Repeated measures ANOVA was used to make comparisons between conditions, and Tukey's post-hoc tests were used for pairwise comparisons. Alpha was set at $p < .05$ to achieve statistical significance.

RESULTS

The descriptive statistics of the 10 male and 10 female subjects who participated in the study are presented in Table 1.

Table 1. Descriptive physical characteristics of the subjects.

Gender	Number of Subjects	Age	Height (cm)	Weight (kg)
Females	10	24 ± 6.0	168 ± 6.1	64 ± 10.5
Males	10	22 ± 0.9	178 ± 5.8	77 ± 11.1
Overall	20	23 ± 4.4	172 ± 8.1	70 ± 12.5

The results of the physiological responses are presented in Table 2, Figure 1, and Figure 2. There were significant differences ($p < .05$) in VO_2, heart rate, RPE, and Kcals/min between all three trials. These results were consistent for males, females, and

overall. Males had significantly ($p < .05$) higher heart rate and lower Kcal/min when compared to women for all conditions.

Table 2. Average Physiological Measurements of the Subjects from Each Trial

	Unaided Walking	Powerbelt Base Unit	Powerbelt + Power Pak 1
Heart Rate			
Females	105 ± 6.1	121 ± 14.6 ‡	132 ± 13.7 ‡
Males	98 ± 9.1 *	112 ± 12.3 * ‡	117 ± 15.1 * ‡
Overall	101 ± 8.2	117 ± 13.9 ‡	125 ± 16.0 ‡
VO_2 $ml \cdot kg^{-1} \cdot min$			
Females	15.0 ± 2.54	18.6 ± 2.23 ‡	20.3 ± 2.72 ‡
Males	6.2 ± 1.86	20.0 ± 2.02 ‡	21.3 ± 2.01 ‡
Overall	15.6 ± 2.25	19.3 ± 2.20 ‡	20.8 ± 2.38 ‡
Kcal/min			
Females	4.7 ± 1.08	5.8 ± 0.94 ‡	6.3 ± 0.71 ‡
Males	6.1 ± 0.95 *	7.6 ± 1.31 * ‡	8.1 ± 1.41 * ‡
Overall	5.4 ± 1.22	6.7 ± 1.43 ‡	7.2 ± 1.41 ‡
RPE			
Females	9 ± 1.7	10 ± 1.7 ‡	12 ± 1.2 ‡
Males	9 ± 1.1	10 ± 1.1 ‡	12 ± 1.0 ‡
Overall	9 ± 1.4	10 ± 1.4 ‡	12 ± 1.1 ‡

* Significantly different from Females ($p < .05$)
‡ Significantly different from Unaided Walking
Significantly different from Powerbelt Base Unit

Figures 1 and 2 present average HR and VO_2 data for all subjects over the entire 30 minute testing sessions.

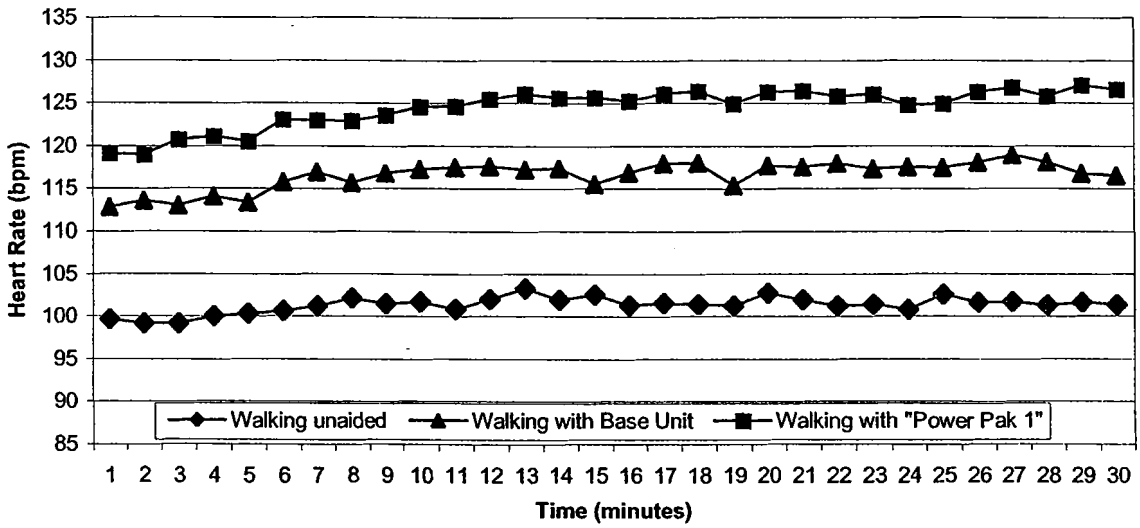

Figure 1. The average heart rate response of all subjects for each trial.

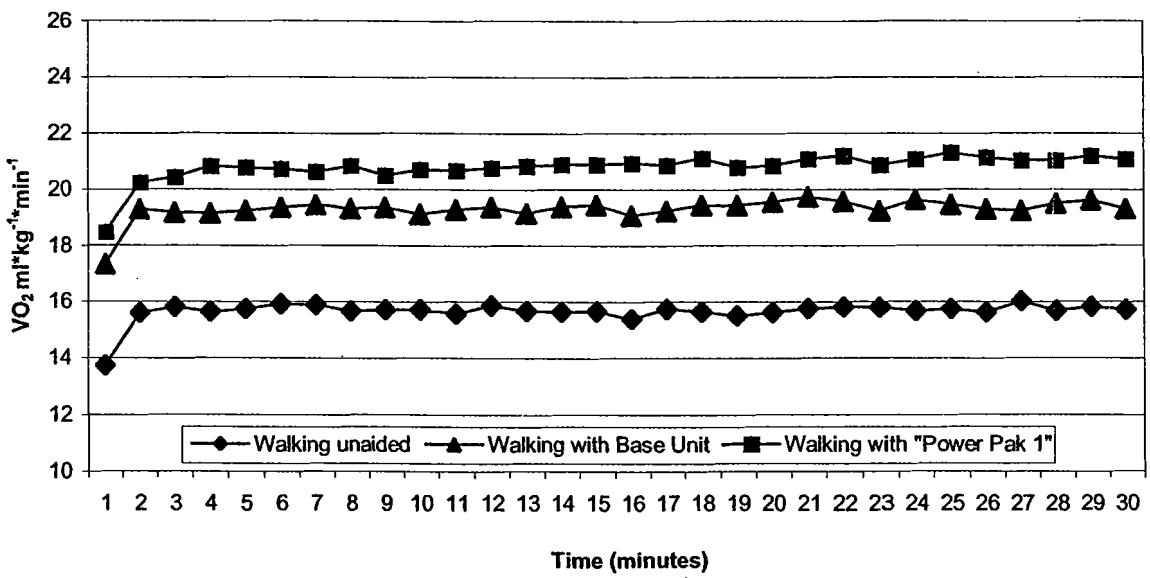

Figure 2. The average VO_2 response of all subjects for each trial.

DISCUSSION

The purpose of this investigation was to determine the physiological responses to walking with the Powerbelt base unit and the Powerbelt with Power Pak 1 for 30 continuous minutes.

In the current study, the use of the Powerbelt base unit increased the energy cost of walking by 25%, and the use of Power Pak 1 increased the energy cost of walking by 35%, when compared to walking alone. These increases were slightly lower than those found in a previous Powerbelt study done by Zedaker, Naser, and Porcari (16). They found that walking for three minutes at 3.0 mph with the Powerbelt base unit increased VO_2 by 42% when compared to unaided walking, and walking at the same speed with Power Pak1 increased VO_2 by 46% over unaided walking. The main reason for these larger increases probably relates to the length of time for each trial. It is speculated that a subject who knows a specific event will only last for a short amount of time (3 minutes) may put forth a more enthusiastic effort, whereas if subjects know a trial will last 30 minutes they may try to preserve energy, thus eliciting lower VO_2 responses.

The energy cost increases found in the current study were slightly higher than most previous findings in which other walking adjuncts were tested. Abadie (1) found that walking with hand weights or wrist weights increased VO_2 by 12.4 to 16.2% compared to unaided walking, depending upon the weight used. A study done by Amos, Porcari, Bauer, and Wilson (3) found 12% increases in oxygen consumption while walking with 2.5 lb wrist weights on each wrist. Studies investigating physiological responses to walking with poles found average increases of 18% in VO_2 (10,12,15), while

studies investigating VO_2 increases while walking with weighted vests have found increases ranging from 3 to 16%. (6,14).

The addition of the Powerbelt base unit while walking resulted in a 15 bpm higher HR response compared to walking alone, while Power Pak 1 resulted in a 23 bpm higher HR response. The 15% increase in HR with the Powerbelt base unit, and the 23% increase in HR with Power Pak1 were also slightly lower than those found in the previous Powerbelt study (16), which found 27 and 32% increases, respectively. Again, this may be due to the longer trial duration of the current study. The magnitude of these changes were again found to be higher when compared to hand weight, wrist weight, and ankle weight studies in which average heart rate increases ranged from 3 to 10% (1,3,7,9). These increases were also higher than those found in walking pole studies, in which average heart rate increases ranged from 9 to 16% (10,12), and weighted vest studies in which average heart rate increases ranged from 5 to 21% (6,14).

Ratings of perceived exertion (RPE) values were significantly higher with both the Powerbelt base unit and Power Pak 1, when compared to unaided walking. The current study found the average RPE while walking with the Powerbelt base unit was 10, and walking with the Power Pak 1 was 12. Zedaker, Naser, and Porcari (16) found slightly higher RPE values at 13 and 15, which were probably related to the higher exercise intensity.

Overall, the use of the Powerbelt with either the base unit or Power Pak 1 increased the energy cost of walking exercise by 25 and 35%, respectively. By using the Powerbelt, individuals may increase the intensity of their workout without having to

increase the frequency or duration of exercise sessions, or the speed of walking. The convenience of the pulleys attached to the belt is an added benefit for those who may not be accustomed to upper body work while walking. Should the arms fatigue, one can simply release the handles, leaving the hands free. The use of a Powerbelt should allow people to realize greater benefits from their walking programs.

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APPENDIX A

INFORMED CONSENT

INFORMED CONSENT FOR
THE PHYSIOLOGICAL RESPONSES TO WALKING WITH A POWERBELT™

I, _____, voluntarily agree to be a subject in a research study designed to determine the physiological responses to walking with a Powerbelt™. I have been shown a Powerbelt™, and have been informed it is a belt with resistance units attached that will allow me to create upper body resistance by pulling on the handles.

I have been informed that I will be required to participate in one 15-30 minute practice session, and three 40-minute testing sessions. The three testing sessions will include walking on a treadmill at a self-selected pace. During two of the testing sessions, I will be using the Powerbelt™ at different resistance levels in addition to walking at my self-selected pace. All testing and practice sessions will take place at the University of Wisconsin-La Crosse Human Performance Laboratory. During all exercise conditions, I will be required to breathe through a scuba-type mouthpiece so that my expired air can be collected and analyzed, and my heart rate will be monitored continuously with a heart rate monitor strapped around my chest.

I have been informed that I can stop the testing at any time I wish. As with any exercise there exists the possibility of abnormal changes occurring (i.e., dizziness, difficulty in breathing, etc.) during the test. If any abnormal observations are noted at any time, the test will be immediately terminated. In addition, I will probably feel tired at the end of the test and may experience some muscle soreness. The testing session will be scheduled at my convenience and will be conducted by a trained graduate

student, who is CPR certified. There is an established emergency protocol in place in the laboratory.

I consent to the publication and/or presentation of this study so long as the information is anonymous and disguised so that no identification of individual subjects can be made. I further have been informed that although a record will be kept of my participation in the experiment, all experimental data will be identified by number only.

I consider myself to be in good health and to my knowledge am not infected with a contagious disease or have any limiting physical condition or disability, especially related to my heart, that would preclude my participation in the testing described above. My questions have been answered to my complete satisfaction. If questions arise at any time during the testing, I may contact the principle investigator (Melissa Hopson: 785-2861, e-mail lisahopson@juno.com), or Thesis Chairperson, Dr. John Porcari (785-8684). Further, I know that I may withdraw from this study at any time without any type of penalty. Contact Garth Tymeson, chair of the UWL Institutional Review Board, if you have any questions about the protection of human subjects (608-785-8155).

Signed: _____ Date: _____

Witness: _____ Date: _____

APPENDIX B

RATINGS OF PERCEIVED EXERTION SCALE

Ratings of Perceived Exertion Scale *

6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
20	

* Borg, G. Perceived exertion: A note on "history" and methods. Med. Sci. Sports 5:90-93, 1973.

APPENDIX C

DATA COLLECTION SHEET

	NAME:_____				AGE:_____						
	ID NUMBER:_____				WEIGHT:_____						
	SPEED:_____										
	Trial 1			Trial 2			Trial 3				
	HR	RPE		HR	RPE		HR	RPE		COMMENTS	
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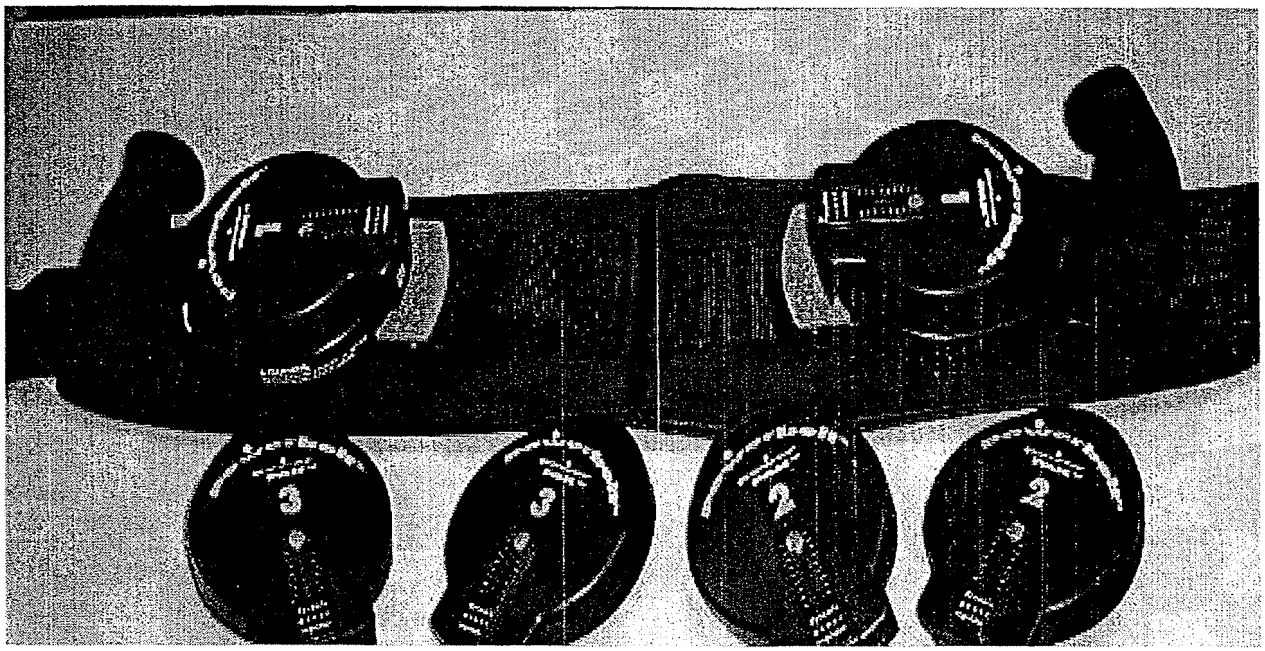
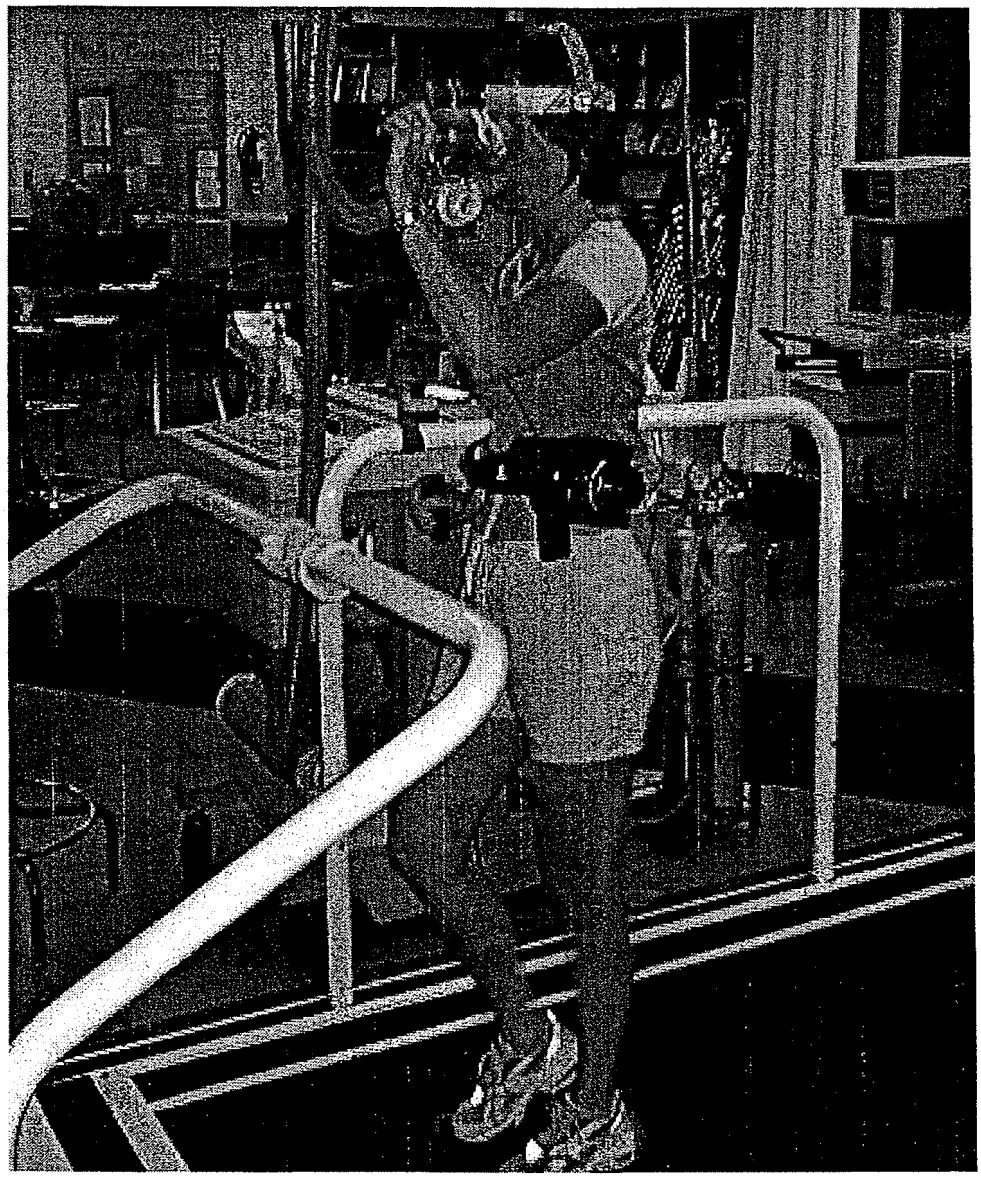
APPENDIX D

PICTURE OF POWERBELT



APPENDIX E

PICTURE OF SUBJECT WITH POWERBELT



APPENDIX F

REVIEW OF RELATED LITERATURE

REVIEW OF RELATED LITERATURE

Introduction

Regular physical activity assists in maintaining an individual's overall health and well being, and provides a variety of physical and psychological benefits. Several studies have indicated that regular physical activity reduces many of the risk factors involved with premature mortality and morbidity (2,24).

With regular activity being so important, it is vital to help people either begin new exercise programs, or keep people who are already active interested in maintaining an exercise program. Every few years a new form of exercise gains popularity; some endure, while others fade away. Some examples of different forms of aerobic exercise include jazzercise, step aerobics, spinning, and Tae Bo. Throughout the years, however, many people have returned to walking as a primary mode of exercise due to its ease, cost-effectiveness, and low injury incidence. People with higher levels of fitness, orthopedic limitations, and/or other physical ailments may find it difficult to reach an intensity level high enough to reach a training threshold with walking alone. To increase the intensity of a walking workout, people are using hand or wrist weights, ankle weight, weighted vests, walking poles, and Powerbelts. The following related literature will review studies on the aforementioned walking adjuncts.

Hand, Wrist, and Ankle Weights

Many studies have been conducted to determine the physiological and metabolic

responses to walking with hand weights, wrist weights, and ankle weights. In 1990, a study was done by Abadie (1) to investigate the responses of healthy individuals while walking on an 8% grade using 6 lb. weights, which were either wrist weights or hand weights. Heart rates (HR) were found to increase by 7 to 10%, with wrist weights and hand weights, respectively. Relative VO_2 was also found to increase with the addition wrist weights and hand weights by 16.2 and 12.4%, respectively.

Another study, done by Graves, Martin, Mittenberger, and Pollock (11) evaluated the energy cost of exercise, comparing hand weights, wrist weights, and ankle weights. Twelve sedentary males were randomly assigned three treadmill exercise sessions at 75% of maximal heart rate reserve, and also completed a fourth session at a constant treadmill speed and grade. During walking, HR increased from 147 bpm with no weight to 155-161 bpm with the addition of weights. Energy cost increased 2.4 $ml \cdot kg^{-1}min^{-1}$ for ankle weights, and 3.8 $ml \cdot kg^{-1}min^{-1}$ for hand weights and wrist weights. Overall, both VO_2 and HR were higher with the usage of hand weights and wrist weights when compared to ankle weights.

Auble, Schwartz, and Robertson (3) found that pumping 1, 2, or 3 lb. hand weights while walking increased oxygen consumption. There was a linear relationship between walking speed, arm range of motion, the amount of weight carried and VO_2 responses. The results showed that VO_2 increased by 113 to 225%, or 17 to 43 $ml \cdot kg^{-1}min^{-1}$, above unweighted walking.

In 1994, Evans, Potteiger, Bray, and Tuttle (9) tested 19 volunteers during eight randomly assigned 10-minute submaximal exercise bouts at either a self-selected constant

speed, or at a constant heart rate. They tested with no hand weights or with hand weights weighing 4.5, 1.36, or 2.27 kg. It was found that 1.36 and 2.27 kg hand weights significantly increased metabolic responses by 6 to 9%, respectively, during constant speed, while hemodynamic responses increased significantly across all trials. Systolic blood pressure increased by 6, 5, and 11% for .45, 1.36, and 2.27 kg weights, respectively, while diastolic blood pressure increased by 6, 9, and 12%, respectively. It was suggested that due to these responses in hemodynamics, using hand weights may be contraindicated in some populations.

Graves, Pollock, Montain, Jackson, and O'Keefe (12) also found that gripping hand weights resulted in exaggerated blood pressure responses, therefore suggesting that using hand weights may not be desirable for some populations. The subjects, 12 untrained men, completed three submaximal and two maximal tests. Systolic blood pressures while using 1 lb hand weights increased an average of 7.3 mmHg, and while using 3 lb hand weights, the systolic blood pressures increased an average of 14.4 mm Hg. Diastolic blood pressures rose an average of 2.1 and 5.2 mm Hg while using the 1 lb and 3 lb hand weights, respectively. These were significant increases over walking without hand weights at the same percentage of heart rate reserve. Ratings of perceived exertion (RPE), HR, and VO_2 were significantly greater with the addition of hand weights when compared to unweighted walking at the same grade and speed.

Owens, al-Ahmed, and Moffatt (18) studied the effects of walking and running with hand weights on oxygen consumption, HR, and RPE. The subjects carried hand weights weighing 1, 3, and 5 lbs. per hand while walking for 5 minutes on a 4 % grade at

speeds of 4.8 and 6.4 km/hr. The subjects were told to swing the arms normally. At these speeds, there were no significant increases in VO_2. It was concluded that walking with hand weights of 2.27 kg or less while maintaining normal arm swing is an insufficient stimulus to significantly increase VO_2 or HR.

In 1988, a study conducted by Makalous, Araujo, and Thomas (15) reported that obese adults who walked with 1 lb. hand weights showed VO_2 increases of 7 % from 1.086 $L \cdot min^{-1}$ with no weight to 1.168 $L \cdot min^{-1}$ with hand weights. These subjects, however, were instructed to walk with exaggerated arm movements. HR were also found to increase by 6% from 120 bpm with no weight to 127 bpm with hand weights.

Another study (27) showed that trained men who walked at 3.5 mph or ran at 7.0 mph on a treadmill with 5 lb. weights in each hand significantly increased oxygen consumption. The subjects walked and ran with no weight, 1 lb., or 5 lb. weights. It was concluded that hand weights could help increase exercise intensity without increasing speed. The results also suggest that no pressor response was elicited by carrying up to 5 lb. in each hand. Rippe (22), however, suggests that carrying weights over 3 lb. is not recommended, as swinging higher weights may result in overuse-type injuries, due to the excessive strain on arm and shoulder musculature. It may also be difficult to use weights above 3 lb. continuously for any significant length of time.

Bhambhani, Burnham, Singh, and Gomes (5) recruited eight male subjects who performed eight running tests. Each test was performed at self-selected speeds, either without weight or with 3.5, 7, or 10.5 lb. weights equally distributed on the ankles or wrists. It was found that the oxygen consumption and HR increased as a linear function

of the additional weight placed at either anatomical location. It was also reported that the magnitude of these responses were significantly higher with ankle weights as compared to wrist weights.

A study done by Amos, Porcari, Bauer, and Wilson (4) found that cardiac patients using 2.5 lb hand weights had a 13 bpm increase in HR and a 21% increase in caloric expenditure and oxygen consumption, compared to unaided walking. Using 2.5 lb. ankle weights increased HR 4 bpm, and increased energy costs by only 1%. No abnormal ECG changes or symptoms were elicited due to using the weights.

When weights were added to the lower extremities, Martin (16) reported the energy cost, oxygen consumption, and the HR associated with running were increased. When loads of .25 or .50 kg added to the feet, VO_2 increased by 3.3 and 7.2 %, respectively. When the loads were added to the thigh, the VO_2 increased by 1.7 and 3.5% respectively.

There are other considerations to consider when discussing weighted running. In a study done by Claremont and Hall (7), the effects of extremity loading upon running mechanics and energy expenditure were studied, and although it was found that VO_2 increased as a linear function of increased loading, the values were not statistically significant. The small increases in energy expenditure along with the increased force of impact discredit running with added weight loads. It was suggested that a more desirable alternative to carrying weights to increase the intensity of a running workout, would be to increase training speed and/or distance. Rippe (22) also found that using ankle weights to increase workout intensity may put added stress on knee ligaments and may alter gait

mechanics. Thus, it follows that increasing speed or distance would be a safer way to increase workout intensity during running.

Weighted Vests

Studies have also been conducted to investigate the physiological responses to walking with weighted vests. A study done by Walcott et al. (25) studied HR and VO_2 responses to walking at 3.5 and 4.0 mph with a weighted vest of either 0, 10, 20, 30, or 40% of body weight. Both males and females had significant increases in VO_2 and HR. It was found that VO_2 increased an average of 9.3, 19, 27.8, and 40.5% for loads of 10, 20, 30, and 40% of body weight over unweighted walking, respectively, and HR increased an average of 4.5, 10.5, 15.5, and 20.5% over unaided walking, for the same loads, respectively. The authors concluded that females had a significantly greater response than males for each speed and load carried, as females walking at 3.5 mph showed 4 and 10% increases in VO_2 with the addition of 10 and 20% of body weight, respectively. There were also 11 and 21% increases in VO_2 with the same weights at 4.0 mph.

Engels and Wirth (8) conducted a study to determine the physiological responses to constant speed walking while wearing a weighted vest. Subjects walked at 3.0 mph and 0% grade for 10 minutes during each test. The weighted trials used vests at 5, 15, 20, and 25% of the subjects body weight. While values for VO_2, HR, and RPE increased significantly with weight load increases, the greatest increase in VO_2 occurred while walking with the weighted vest at 25% of body weight. This increase equaled 1.92 $ml \cdot kg^{-1} \cdot min^{-1}$, which was a 16% increase.

It has been shown that to significantly increase oxygen consumption while walking with a weighted vest, more than 40% of a person's body weight must be carried (8, 25). This amount of weight produces increased force on the ankle, knee, and hip, and possibly puts extra compressive force on the spine (22).

These values may slightly increase if an activity is being performed that requires lifting the weight against gravity, such as stair stepping or walking on a grade. It has also been stated that the main benefit of weighted vests may be when they are worn during sporting activity, which may increase overall body quickness (19).

Walking Poles

Physiological responses to the use of walking poles has been a more recent area of study. In a study done by Rodgers, Van Heest, and Schachter (23), female subjects completed two randomly assigned trials of treadmill walking with and without Exerstriders. It was shown that there was an 11% increase in VO_2, a 9% increase in HR, and a 17% increase in caloric expenditure while walking with Exerstriders when compared to unaided walking.

A similar study done by Porcari, Hendrickson, Walter, Terry and Walsko (20) found that VO_2, HR, and caloric expenditure increased by 23, 16, and 22%, respectively, when walking with walking poles. The study consisted of 32 volunteers who completed a maximal treadmill test and 2 randomly assigned walking trials, one with walking poles and one without. Each subject completed 20 minutes on a level treadmill at a self-selected pace for each trial. It was also found that RPE values averaged 1.5 units higher with the use of walking poles.

In 1996, Walter, Porcari, Brice, and Terry (26) designed a study to assess the safety of walking with walking poles in cardiac rehabilitation patients. After allowing the subjects time to practice, each subject completed two 8 minute trials on a level treadmill. One trial consisted of walking with poles, while the other consisted of unaided walking. The authors found that walking with the poles increased VO_2 by 21% when compared to unaided walking. HR and BP also rose, and these responses were not thought to be due to a pressor response. These findings indicate that using walking poles is a safe and effective way for Phase III and IV cardiac rehabilitation patients to increase the intensity of a walking workout. Walking with the poles increased the intensity by 68 to 78% of maximal HR, and increased caloric expenditure by 22%.

Another study (21) consisted of 92 inactive women who walked for 12 weeks. One group of women walked with Exerstriders, while the other group walked without Exerstriders. There were no significant differences between training HR or increases in aerobic power between the two groups, however, the Exerstrider group had a walking speed that averaged 0.3 mph less than the unaided walking group. It was concluded that significant physiological responses could occur at lesser speeds.

Brunelle and Miller (6) found that another benefit to walking with poles may be the decreased forces upon the feet. It was found that walking with Exerstriders decreased the forces on the feet by up to 26% during walking. These decreases may be helpful for people with hip and or lower extremity problems, as well as reduce the strain placed on the ankles, knees, and hips.

Powerbelts and Aerobelts

Aerobelts and Powerbelts are two of the latest types of exercise equipment being introduced to increase the intensity of a workout. Both units wrap around the waist like a belt, but where the Aerobelt has surgical tubing attached on both sides of the belt, the Powerbelt has two pulleys, one on each side. As an individual walks or runs, the tubes or the handles on the pulleys are pulled by the arms. The tubes or pulleys create a resistance for the individual to pull against. Individual preference can allow for different types of arm swings, but it has been found that the most benefit is derived from an exaggerated arm motion (15). In several studies it was shown that the use of an Aerobelt increased the energy demands for step aerobics and jogging by approximately 54% (13,17). Walking while using an Aerobelt has also been shown to increase VO_2 by 42% and HR by 27% (14).

In a study testing responses to a Powerbelt (28), 12 volunteers who were regular exercisers, participated in two trials. Each trial, held on separate days, consisted of a subject exercising on treadmill at either a walk of 3.0 mph or a run of 5.5 mph under 7 different conditions. The conditions were walking normally, walking with raised arms, walking while swinging 2 lb. hand weights, walking with a Powerbelt base unit, and walking with a Powerbelt and Power Paks 1, 2, and 3. Each condition lasted 3 minutes in duration with a 3 minute rest period between bouts. It was found that while walking, all conditions increased HR above walking normally. Specifically, the Powerbelt base unit and Power Paks 1, 2, 3 raised the HR by 27, 32, 36 and 44 bpm, respectively. Similar results were found with increases in VO_2 over normal walking. VO_2 while walking with

the Powerbelt base unit increased by 42% , while walking with the Powerbelt and Power Paks 1, 2, and 3 increased by 46, 54, and 64%, respectively. The running trials produced similar results with HR increases of 23, 26, 30, and 32 bpm, respectively, for the base unit and Power Paks 1-3, although percentage increases in VO_2 were less dramatic than seen in the walking trials, with only 2% increases for both Power Paks 2 and 3. Overall, it was concluded that walking with a Powerbelt would produce more desirable results than running with a Powerbelt, as running with a Powerbelt showed smaller increases when compared to walking. However, walking using Power Paks 2 and 3 probably could not be maintained for long periods of time.

Another study focused on using a Powerbelt during a choreographed aerobic session (10). Twelve female subjects, between 22 and 40 years of age, each performed pre-planned choreographed movements to an aerobic dance video. The trials consisted of aerobics alone, aerobics with a Powerbelt base unit, and aerobics with 1 to 3 lb. hand weights, with each trial lasting 5 minutes. It was found that both the Powerbelt and hand weights increased VO_2 by 9 and 8%, and increased HR by 11 and 8 bpm, respectively. These results were consistent with the results from the running trials in the aforementioned study.

Although the upper levels of the Power Paks, specifically Power Pak 2 and 3, may be difficult to sustain for a significant length of time, they may be useful for interval training. Another benefit of using a Powerbelt is if arm fatigue becomes a problem, the pulleys simply retract into a casing attached to the belt, leaving the hands free.

Summary

As shown from the literature, numerous studies have evaluated the effects of various types of load carriage on the physiological responses to exercise. In many studies, walking with hand, wrist, or ankle weights increased the intensity of a walking workout. The results show increases in energy expenditure of 5 to 15% over that of walking without weights. However, it is thought that exaggerated arm movements are responsible for any significant increases. Researchers have also found increases in energy expenditure when walking with weighted vests. Increases ranged from 3 to 7%, however, the loads needed to obtain the higher increases would probably be uncomfortable for most people. Walking poles have also shown favorable increases in HR (9 to 16%) and VO_2 (11 to 22%) over unaided walking. It is also thought that walking with poles have an added benefit of decreasing the ground forces on the feet, which could be beneficial for people with orthopedic problems. Finally, researchers have also reported increases in HR and energy expenditure with the use of Powerbelts and Aerobelts. The increases in VO_2 ranged from 25 to 50%, and are among the highest seen for any modality. Another advantage is that if the arms get tired, a person can simply release the handles and continue the workout.

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Note regarding page 36:

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