ABSTRACT

Dockter, C. R. The physiological responses to walking and stepping while wearing a weighted vest. MS in Adult Fitness/Cardiac Rehabilitation, December 1997, 30pp. (J. Porcari)

Fifteen female Ss, age 21-39, were tested under a variety of conditions while wearing a weighted vest. The modalities tested include walking on a treadmill at 3.5 mph at 0 and 10% grades, stepping on a StairMaster Gauntlet at 52 steps/min, stepping on a Tectrix Stair-stepper at 40 feet/min, and stepping up and down on an 8 inch aerobic step at a metronome rate of 112. For each modality Ss exercised for 5 minutes under each of the following conditions: no weight, 5%, and 10% of body weight (BW). Every minute VO_2, HR, RER, and Kcal/min were measured. RPE was measured prior to the 5th minute of each condition. In general, at 5% BW VO_2 and Kcal/min increased 6%, RPE averaged 1 unit higher, and HR increased 4 bpm. At 10% BW, VO_2 and Kcal/min increased 11%, RPE averaged 2 units higher, and HR increased 7 bpm. It is concluded that the use of the weighted vest can increase the intensity of walking and stepping exercises, therefore providing additional benefits to one's exercise program.

THE PHYSIOLOGICAL RESPONSES TO WALKING AND STEPPING WHILE WEARING A WEIGHTED VEST

A MANUSCRIPT STYLE THESIS PRESENTED

TO

THE GRADUATE FACULTY

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THESIS FINAL ORAL DEFENSE FORM

Candidate: Cynthia Renae Dockter

We recommend acceptance of this thesis in partial fulfillment of this candidate's requirements for the degree:

Master of Science in Adult Fitness/Cardiac Rehabilitation

The candidate has successfully completed the thesis final oral defense.

Thesis Committee Chairperson Signature — Date: 6/27/97

Thesis Committee Member Signature — Date: 6/27/97

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

Associate Dean, College of Health, Physical Education, and Recreation — Date: 7-3-97

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INTRODUCTION

Over the years, the population has become interested in how to obtain the greatest benefits from their exercise program. One factor which influences these benefits is the intensity or how hard a person exercises. In attempts to increase intensity, people have used external weights in the form of wrist, ankle, and hand-held weights.

Research has shown that with the use of either hand-held or ankle weights, people can increase the intensity of a specific exercise without having to increase the speed of movement (1,3,13). Increasing intensity without increasing speed is important for low fit people and special populations who cannot run or are limited to the speed at which they can walk. Amos, Porcari, Bauer, and Wilson (3) found that walking with 2.5 lb weights significantly increased oxygen consumption by 10% when using ankle weights and by 21% when using wrist weights. Abadie (1) studied the effects of walking up an 8% grade using 6 lb hand and wrist weights. He reported that relative oxygen consumption increased 12.4 and 16.2% with the addition of hand and wrist weights, respectively.

One possible problem associated with the use of hand weights may be the occurrence of an exaggerated blood pressure response (7). This response is most likely do to gripping of the weight and may be contraindicated for certain patient populations (6).

Other investigators have focused on load carriage closer to the body. Schram and Hanson (10) studied the effects of level walking while wearing a weighted backpack on oxygen consumption and heart rates of cardiac patients. It was discovered that oxygen consumption increased significantly by an average of 12% and heart rates by 6-7 bpm with each addition of 5 kg weight.

Walcott et al. (12) studied level walking while wearing a weighted vest with 0, 10, and 20% of body weight. For females walking at 3.5 mph it was concluded that oxygen consumption increased 8 and 16.8%, respectively, with the addition of 10 and 20% of body weight. Heart rates were found to increase by 4 and 10% under the same conditions.

A relatively new product on the market is an adjustable weighted vest which is designed to be worn while exercising (SmartVest, Training Zone Concepts, Flint, MI). The idea behind the weighted vest is to provide a much safer alternative to carrying weights or having them strapped to the body. Weights in a vest form also allow freedom of the hands which is beneficial for using various pieces of exercise equipment, such as a stair-stepper. This freedom of the hands enables a person to stabilize their balance, and makes getting on and off the equipment much easier. Overall, individuals could obtain greater benefits from their exercise workouts if this added weight was found to increase exercise intensity.

Few studies exist which focus on exercising on various modalities while using extra weight. Most of the studies have only focused on walking on level or up slight grades. It was hypothesized that wearing the weighted vest while doing a variety of stepping related exercises, where a person is required to lift the weight upwards against gravity, might enhance the physiological responses and increase the intensity of the exercise. The purpose of this study was to determine the physiological responses of walking and performing a variety of stepping related exercises while wearing a weighted vest.

METHODS

Subjects

The subjects for this research study included 15 college-aged females from the University of Wisconsin-La Crosse (UW-L). All of the subjects were assumed to be in good health at the time of testing and were free from known heart disease or other medical conditions which would contraindicate exercise. Prior to the testing session, the participant was asked to read, sign, and date the informed consent (see Appendix A) that described the procedures and risks involved with the study which were previously approved by the UW-L Institutional Review Board. The participant also answered a Physical Activity Readiness Questionnaire (see Appendix B) (2). At this time, the investigator answered any questions that the participant may have had about the testing procedures.

Testing Procedures

Each participant reported on five separate days for testing and were informed to wear comfortable clothing and shoes. Every participant was required to complete one of the following tests on each day: 1) walk on a treadmill at 3.5 mph and 0% grade, 2) walk on a treadmill at 3.5 mph and 10% grade, 3) step on a Tectrix Stair-stepper at 40 feet/min, 4) step on a StairMaster Gauntlet at 52 steps/min, and 5) step up and down on an 8 inch aerobic step at a metronome rate of 112. On each day the participant completed each of the following conditions: 1) no weight, 2) weighted vest with 5% of body weight, and 3) weighted vest with 10% of body weight, on each modality, in random order. The subject had a 3 min warm-up and then exercised for 5 min with each condition. In between each condition the subject rested to allow the heart rate to decrease within 10 beats of resting rate.

Each participant was weighed with their shoes off to the nearest quarter pound. Five and 10% of the measured body weight was then calculated for the weighted vest. A Polar Vantage XL (Polar Inc., Stamford, CT) heart rate monitor was put around the chest of the participant. The weighted vest was then fitted for the participant and the appropriate weight was added when needed. The participant was also fitted with a mouthpiece and headgear for the measurement of oxygen consumption (VO_2). The Quinton Metabolic Cart (QMC, Quinton Instrument Company, Seattle, WA) was used to measure VO_2. Prior to each test, the QMC was calibrated by analyzing gases with known concentrations of O_2 and CO_2. A 3.0 l syringe was used to calibrate flow meter volumes. Oxygen consumption, heart rate (HR), respiratory exchange ratio (RER), and energy expenditure (Kcal/min) were monitored throughout the tests. Prior to the 5th min, the participant was asked to rate her perceived exertion (RPE) using the 6-20 Borg Scale (4).

Statistical Analysis

Data for each modality were analyzed with a one-way analysis of variance with repeated measures to determine if there was a significant difference in the physiological responses to the 0, 5, and 10% of body weight conditions. A Tukey's post-hoc test was performed to determine pairwise differences when a significant F ratio was found. The alpha level was set at 0.05 to achieve statistical significance.

RESULTS

Fifteen female subjects from UW-L volunteered to participate in this study. The physical characteristics of the subjects are summarized in Table 1.

Table 1. Physical characteristics of subjects (N = 15)

	Mean ± Standard Deviation	Range
Age (yr)	25.33 ± 4.03	21 - 39
Height (in)	65.08 ± 2.72	61 - 70
Weight (lb)	127.2 ± 15.33	96 - 153
5% of Body Weight Used (lb)	6.6 ± .83	5 - 8
10% of Body Weight Used (lb)	12.7 ± 1.53	10 - 15

The physiological responses to walking on the treadmill at 3.5 mph and 0% grade are presented in Table 2.

Table 2. Physiological responses to walking on the treadmill at 3.5 mph, 0% grade

	No Weight	5%	10%
VO_2	15.3 ± 2.14	15.6 ± 2.01	16.9 ± 1.95 #
HR	100 ± 15.67	103 ± 15.53 *	106 ± 14.59 #
RPE	8.5 ± 1.55	9.5 ± 1.69 *	10.6 ± 2.03 #
RER	.90 ± .05	.91 ± .05	.91 ± .04
Kcal/min	4.36 ± .85	4.45 ± .87	4.80 ± .79 #

All values represent means ± standard deviations.
* Significantly different from the no weight condition ($p < 0.05$).
\# Significantly different from the no weight and 5% of body weight conditions ($p < 0.05$).

It was found that the addition of 5% of body weight significantly ($p < 0.05$) increased HR and RPE compared to the no weight condition. The addition of 10% of body weight significantly ($p < 0.05$) increased VO_2, HR, RPE, and Kcal/min compared to both the no weight and 5% of body weight conditions. With 10% of body weight, VO_2 increased 1.6 $ml \cdot kg^{-1} \cdot min^{-1}$ (10.5%) and HR increased 6 bpm (6%) compared to the no weight condition. The RER values were not significantly ($p > 0.05$) different.

The physiological responses to walking on the treadmill at 3.5 mph and 10% grade are presented in Table 3.

Table 3. Physiological responses to walking on the treadmill at 3.5 mph, 10% grade

	No Weight	5%	10%
VO_2	28.5 ± 3.16	29.9 ± 3.43 *	31.6 ± 3.30 #
HR	146 ± 19.58	149 ± 18.50	153 ± 19.12 #
RPE	11.3 ± 2.38	12.4 ± 1.96 *	13.7 ± 2.09 #
RER	.94 ± .04	.95 ± .04 *	.97 ± .05 #
Kcal/min	8.16 ± 1.32	8.57 ± 1.41 *	9.10 ± 1.47 #

All values represent means ± standard deviations.
* Significantly different from the no weight condition ($p < 0.05$).
# Significantly different from the no weight and 5% of body weight conditions ($p < 0.05$).

It was determined that the addition of 5% of body weight significantly ($p < 0.05$) increased VO_2, RPE, RER, and Kcal/min compared to the no weight condition. The addition of 10% of body weight significantly ($p < 0.05$) increased all of the physiological responses that were tested. It was found that VO_2 increased 3.1 $ml \cdot kg^{-1} \cdot min^{-1}$ (10.9%) and HR increased 7 bpm (4.8%) from no weight to the 10% of body weight condition.

The physiological responses to stepping on the StairMaster Gauntlet at 52 steps/min are presented in Table 4.

Table 4. Physiological responses to stepping on the StairMaster Gauntlet at 52 steps/min

	No Weight	5%		10%	
VO_2	23.3 ± 1.24	24.8 ± 1.34	*	25.8 ± 1.51	#
HR	134 ± 22.52	138 ± 22.49	*	142 ± 23.22	#
RPE	9.4 ± 1.64	11.1 ± 2.25	*	12.2 ± 2.21	#
RER	.92 ± .03	.93 ± .02		.93 ± .02	
Kcal/min	6.67 ± .87	7.13 ± .95	*	7.41 ± .98	#

All values represent means ± standard deviations.
* Significantly different from the no weight condition ($p < 0.05$).
\# Significantly different from the no weight and 5% of body weight conditions ($p < 0.05$).

It was found that with the addition of both 5 and 10% of body weight, VO_2, HR, RPE, and Kcal/min were significantly ($p < 0.05$) higher compared to the no weight condition. Oxygen consumption increased by 2.5 $ml \cdot kg^{-1} \cdot min^{-1}$ (10.7%) and HR increased by 8 bpm (6%) from the no weight to 10% of body weight condition. The RER values obtained were not significantly ($p > 0.05$) different.

The physiological responses to stepping on the Tectrix Stair-stepper at 40 feet/min are presented in Table 5. All of the physiological responses tested were found to significantly ($p < 0.05$) increase with the addition of both 5 and 10% of body weight conditions.

Table 5. Physiological responses to stepping on the Tectrix Stair-stepper at 40 feet/min

	No Weight	5%	10%
VO_2	25.7 ± 1.38	27.2 ± 1.78 *	28.4 ± 1.35 #
HR	146 ± 21.86	149 ± 20.57 *	153 ± 21.60 #
RPE	10.9 ± 1.87	11.9 ± 1.53 *	13.4 ± 1.99 #
RER	.96 ± .03	.98 ± .05 *	1.00 ± .05 #
Kcal/min	7.42 ± .99	7.91 ± 1.15 *	8.29 ± 1.19 #

All values represent means ± standard deviations.
* Significantly different from the no weight condition ($p < 0.05$).
# Significantly different from the no weight and 5% of body weight conditions ($p < 0.05$).

It was found that oxygen consumption increased 2.7 $ml \cdot kg^{-1} \cdot min^{-1}$ (10.5%) and HR increased 7 bpm (4.8%) from the no weight to 10% body weight condition.

The physiological responses to stepping up and down on an 8 inch aerobic step at a metronome rate of 112 are presented in Table 6. It was found that VO_2, HR, RPE, and Kcal/min were significantly ($p < 0.05$) higher for both the 5 and 10% conditions compared to the no weight condition. Oxygen consumption increased 2.1 $ml \cdot kg^{-1} \cdot min^{-1}$ (9.6%) and HR increased by 9 bpm (7.1%) from the no weight to the 10% weight condition. The RER values obtained were not significantly ($p > 0.05$) different.

Table 6. Physiological responses to stepping on an 8 inch aerobic step at a rate of 112

	No Weight	5%		10%	
VO_2	21.9 ± 1.57	22.9 ± 1.30	*	24.0 ± 1.76	#
HR	126 ± 20.86	131 ± 21.61	*	135 ± 21.52	#
RPE	10.3 ± 1.34	11.3 ± 1.72	*	12.5 ± 1.92	#
RER	.91 ± .05	.91 ± .05		.91 ± .04	
Kcal/min	6.21 ± .74	6.52 ± .85	*	6.85 ± .91	#

All values represent means ± standard deviations.
* Significantly different from the no weight condition ($p < 0.05$).
# Significantly different from the no weight and 5% of body weight conditions ($p < 0.05$).

DISCUSSION

The purpose of this investigation was to determine if adding external weight in the form of a weighted vest would significantly increase the physiological responses to various walking and stepping modalities. The results of this investigation will be compared to other research studies that focus on walking with hand, wrist, or ankle weights, weight loaded walking and stepping, and walking with a weighted vest.

For the five modalities used in this study, oxygen consumption increased an average of 2.4 $ml \cdot kg^{-1} \cdot min^{-1}$ (10.4%) with 10% of body weight compared to the no weight condition. During the walking trials, the increase in oxygen consumption from 0 to 10% weight was dependent on the grade difficulty. For instance, at a 0% grade VO_2 increased by 1.6 ml·kg^{-1}·min^{-1} compared to 3.1 ml·kg^{-1}·min^{-1} at a 10% grade. However, during the stepping modalities similar increases in oxygen consumption were found ranging from 2.1 to 2.7 ml·kg^{-1}·min^{-1}.

The results obtained for oxygen consumption from the current study are similar to other research studies (3,7,13). These studies concluded that walking with 2.5 and 3 lb ankle weights increased oxygen consumption by 1.7 (10%) and 2.4 ml·kg^{-1}·min^{-1}, respectively. Abadie (1) discovered a 12.4% increase in relative VO_2 while using 6 lb hand weights and walking up an 8% grade. Schram and Hanson (10) also reported that walking at 3 mph and 0% grade using 5 kg increments increased VO_2 by 1.5 ml·kg^{-1}·min^{-1} for each 5 kg load. This is comparable to the current study where a 1.6 ml·kg^{-1}·min^{-1} increase in VO_2 was found while walking at 3.5 mph and 0% grade using a mean weight of 12.7 lb. Investigators (9) using a rucksack for external weight demonstrated that much higher weights are necessary for similar increases in oxygen consumption. For example, walking with 31.5 kg increased VO_2 an average of 10% at speeds of 3.0 and 3.6 mph.

The average increase in heart rate for all of the modalities, using 10% weight, was 7 bpm (6%). This represents the same heart rate values reported in the study by Makalous, Araujo, and Thomas (8), which used 1 lb hand weights and exaggerated arm movements. Schram and Hanson (10) also detected a 6-7 bpm increase in HR per 5 kg increment of weight added. Heart rates were generally found to be slightly higher in those studies that used wrist or hand weights (1,3,5,6). Graves, Pollock, Montain, Jackson, and O'Keefe (7) concluded that using 3 lb hand weights increased heart rates by

7-13 bpm. Abadie (1) found heart rates to increase by 11 bpm (8%) with wrist weights and 15 bpm (10.5%) with hand weights. Similar heart rates of 5 and 8 bpm were also reported during bench stepping at a height of 8 inches and the addition of 2.7 and 5.4 kg, respectively (11).

Rating of perceived exertion values were significantly higher with 5 and 10% of body weight for all of the modalities. These values agree with what other research studies have reported (3,7,10). Amos et al. (3) determined that RPE was significantly greater using 2.5 lb hand and wrist weights but not for ankle weights.

Respiratory exchange ratio values were found to increase significantly during two of the modalities. These findings are consistent with other research studies in which RER increased in two and did not increase in another two other studies (3,5,6,8).

Energy expenditure increased in almost every condition. Only one study (8) was discovered that tested for energy expenditure and it was determined to be significantly greater by 0.4 Kcal/min (7%) with the use of 1 lb hand weights. The current study found an average increase of 0.7 Kcal/min (11%) across all five modalities which is consistent with the increase in VO_2.

Walcott et al. (12) studied the responses to level walking with a weighted vest. He reported that for females using 10% of body weight while walking 3.5 mph and 0% grade only increased VO_2 by 8% compared to the 10.5% increase detected in the current study. He also recorded that HR increased by 5 bpm (4%) which is comparable to the 6 bpm (6%) increase found in the current study. Overall, it was determined that females had a significantly greater response than did the males and that the responses were also greater at a speed of 4.0 mph compared to 3.5 mph.

Engels and Wirth (5) also studied the physiological responses to level walking at 3.0 mph while wearing a weighted vest and found similar results. The values for VO_2, HR, and RPE increased significantly with each 5% weight load increment. The greatest increase in VO_2 occurred at 25% of body weight and equaled 1.92 $ml \cdot kg^{-1} \cdot min^{-1}$ (16%) compared to 1.6 $ml \cdot kg^{-1} \cdot min^{-1}$ (10.5%) increase reported in the current study at 3.5 mph and 10% body weight. As in the current study, RER values were not significantly different.

Overall, the use of the weighted vest increased the intensity of walking and stepping exercises. By using the weighted vest individuals may increase the intensity of their workout without having to increase the frequency or duration. The added weight in a vest form would also allow freedom of the hands and should not elicit an exaggerated blood pressure response which is often seen when using hand weights (7).

REFERENCES

1. Abadie, B.R. Physiological responses to grade walking with wrist and hand-held weights. *Res. Q. Exerc. Sport* 61:93-95, 1990.

2. American College of Sports Medicine. *Guidelines for Exercise Testing and Prescription (5th ed.).* Philadelphia, PA: Lea and Febiger, 1995, pp. 13-16.

3. Amos, K. R., J. P. Porcari, S. R. Bauer, and P. K. Wilson. The safety and effectiveness of walking with ankle weights and wrist weights for patients with cardiac disease. *J. Cardiopulmonary Rehabil.* 12:254-260, 1992.

4. Borg, G. Perceived exertion as an index of somatic stress. *Scand. J. Rehabil. Med.* 2:92-98, 1970.

5. Engels, H. J. and J. C. Wirth. Physiological responses to steady-rate walking using an adjustable weighted fitness vest. *Res. Q. Exerc. Sport* 67(March Suppl.): A32, 1996.

6. Graves, J. E., A. D. Martin, L. A. Miltenberger, and M. L. Pollock. Physiological responses to walking with hand weights, wrist weights, and ankle weights. *Med. Sci. Sports Exerc.* 20:265-271, 1988.

7. Graves, J. E., M. L. Pollock, S. J. Montain, A. S. Jackson, and J. M. O'Keefe. The effect of hand-held weights on the physiological responses to walking exercise. *Med. Sci. Sports Exerc.* 19:260-265, 1987.

8. Makalous, S.L., J. Araujo, and T.R. Thomas. Energy expenditure during walking with hand weights. *Physician Sportsmed.* 16:139-148, 1988.

9. Patton, J. F., J. Kaszuba, R. P. Mello, and K. L. Reynolds. Physiological responses to prolonged treadmill walking with external loads. *Eur. J. Appl. Physiol.* 63:89-93, 1991.

10. Schram, V. and P. Hanson. Cardiovascular and metabolic responses to weight-loaded walking in cardiac rehabilitation patients. *J. Cardiopulmonary Rehabil.* 8:28-32, 1988.

11. Stanforth, P. R. and D. Stanforth. The effect of adding external weight on the aerobic requirement of bench stepping. *Res. Q. Exerc. Sport* 67:469-472, 1996.

12. Walcott, G., R. Coleman, M. MacVeigh, et al. Heart rate and VO_2 response to weighted walking. *Med. Sci. Sports Exerc.* 18:S28, 1986.

13. Zarandona, J. E., A. G. Nelson, R. K. Conlee, and A. G. Fisher. Physiological responses to hand-carried weights. *Physician Sportsmed.* 14:113-120, 1986.

APPENDIX A

INFORMED CONSENT

WEIGHTED VEST STUDY
INFORMED CONSENT

I, ________________________, volunteer to be a subject in the weighted vest study to determine the physiological effects of walking and stepping while wearing a weighted vest. I will be required to report on five separate days for testing. Each piece of equipment will be tested on a separate day and include the following: walking on a treadmill at 0% grade, walking on a treadmill at 10% grade, stepping on a Tectrix Stair-stepper at 40 steps/min, stepping on a StairMaster Gauntlet at 52 steps/min, and stepping up on an 8 inch aerobic step at a metronome rate of 112. On each piece of equipment I will be wearing the weighted vest at 0, 5 and 10% of my body weight and will exercise 5 minutes for each condition. In between each condition I will be able to rest and allow my heart rate to return to a resting value. Throughout the tests I will be required to breathe through a mouthpiece for the measurement of oxygen consumption. I will also be required to wear a heart rate monitor and rate my perceived exertion level. I understand that I can stop any individual test at any time, and/or choose not to return.

I understand that this study may involve possible risks such as muscle soreness, dizziness, abnormal blood pressure, irregular heart rate, and in rare instances heart attack, stroke or death. However, the benefits will include new knowledge about the effects of walking and stepping while wearing the weighted vest.

I understand that part of the risk involved with participating in this study is relative to my own state of fitness and to the awareness, care and skill with which I conduct myself. I consider myself to be in good health and to my knowledge I am not infected with a contagious disease or have any limiting physical condition or disability, especially with respect to my heart, that would prevent my participation in the at study described above.

I have been informed and completely understand what is expected of me. I consent to publication of study results so long as the information is anonymous and reported as group results and not individual. Any questions that I had have all been answered to my satisfaction. I have been advised of all possible risks involved and that I may withdraw from this study at any time without a penalty.

Concerns about any aspects of this study may be referred to the principal researcher, Cindy Dockter at (608)787-6072 and/or thesis advisor:

John Porcari
University of Wisconsin-La Crosse
216 Mitchell Hall
La Crosse, WI 54601
(608)785-8684

Subject:____________________________________ Date:____________

Witness:____________________________________ Date:____________

APPENDIX B

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE

Weighted Vest Study

Name: ______________________ DOB: __________ Age: ______

Address: ______________________ Phone: ____________________

____

____

Physical Activity Readiness Questionnaire (PAR-Q)

YES NO 1. Has your doctor ever said that you have a heart condition <u>and</u> that you should only do physical activity recommended by a doctor?

YES NO 2. Do you feel pain in your chest when you do physical activity?

YES NO 3. In the past month, have you had chest pain when you were not doing physical activity?

YES NO 4. Do you lose your balance because of dizziness or do you ever lose consciousness?

YES NO 5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?

YES NO 6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

YES NO 7. Do you know of <u>any other reason</u> why you should not do physical activity?

The above questions have been answered truthfully and to the best of my knowledge. I am not withholding any information regarding my health status which would place me at an increased risk of injury or cardiovascular problems by participating in this exercise program.

Signed: ______________________________ Date: ______________

APPENDIX C

REVIEW OF RELATED LITERATURE

REVIEW OF RELATED LITERATURE

Introduction

As the population has become interested in obtaining greater benefits from their exercise program, intensity is now a main focus of attention. In order to increase the intensity level associated with walking, researchers have studied the use of load carriage while walking. This review will focus on studies evaluating the physiological responses to exercising with load carriage and will include the following: walking and running with hand and ankle weights, weight loaded walking and stepping, and walking while wearing a weighted fitness vest.

Hand and Ankle Weights

In 1990, Abadie (1) studied the responses of healthy individuals while walking up an 8% grade using either 6 lb wrist or hand weights. Relative VO_2 was found to increase by 16.2 and 12.4% with the addition of wrist and hand weights, respectively. Heart rates also increased from 143 bpm with no weight, to 154 and 158 bpm with wrist and hand weights, respectively.

Another study focused on obese adults who walked while carrying 1 lb hand weights with exaggerated arm movements (8). It was reported that oxygen consumption increased 7%, from 1.086 $l \cdot min^{-1}$ with no weight to 1.168 $l \cdot min^{-1}$ with the addition of hand weights. Heart rates were also found to increase significantly from 120 bpm with no weight to 127 bpm with hand weights, which represented a 6% increase.

RER values were not significantly different but the average rate of energy expenditure with the use of hand weights was significantly greater (7%) than no weights.

Auble, Schwartz, and Robertson (3) detected similar results with walking while pumping 1, 2, or 3 lb hand weights. Oxygen consumption increased as the arm range of motion, weight carried, and walking speed increased (2.5, 3.0, 3.5, and 4.0 mph). As a result, VO_2 increased by 17 to 43 $ml \cdot kg^{-1} \cdot min^{-1}$, or 113% to 255% greater than normal walking.

Zarandona, Nelson, Conlee, and Fisher (15) tested 30 trained men who walked and ran on a treadmill with no weights, 1 lb weights, or 5 lb weights in each hand. It was found that walking and running while carrying the 5 lb weights in each hand significantly increased VO_2, while walking only increased heart rate. The results suggest that a pressor reflex was not elicited by carrying up to 5 lb weights in each hand. The oxygen pulse data showed that changes found in heart rate and VO_2 were highly related. Therefore, it was concluded that carrying hand-held weights could help increase exercise intensity, especially for those people who do not want to increase their speed.

In 1988 Claremont and Hall (4) studied the effects of extremity loading upon energy expenditure and running mechanics. Although VO_2 increased from 2.47 to 2.64 $l \cdot min^{-1}$ with increased load carriage, the values were statistically insignificant. Therefore, it was determined that the small increases in energy expenditure, along with the potential for increased force of impact and the discomfort of the weight carriage, discredit running with hand or ankle weights. A more desirable alternative would be to increase speed and/or distance while training.

Martin (9) reported that the energy cost, oxygen consumption, and heart rate associated with running were increased when the amount of load carried on the lower extremities was also increased. The study included loads of .25 and .50 kg which were added to each thigh or foot. As the load on both the thighs and feet increased, so did VO_2 and heart rate. With the addition of .25 and .50 kg weights to the thigh, VO_2 increased by 1.7 and 3.5%. When these weights were added to the feet, VO_2 increased by 3.3 and 7.2%, respectively.

Walking with hand-held weights has become popular, especially for patients with cardiac disease. These weights enable patients to increase the intensity of their walking program and thus get their heart rates into an appropriate training zone. One study compared the effectiveness of walking without weights to walking with 2.5 lb wrist or ankle weights (2). Eighteen male patients in a Phase III and IV cardiac rehabilitation program volunteered for the study. The subjects walked on a treadmill while using either ankle or wrist weights or no weights at all. It was found that the addition of either ankle or wrist weights increased the intensity of walking exercise. Oxygen consumption increased 1.7 $ml \cdot kg^{-1} \cdot min^{-1}$ (10%) using ankle weights and 3.5 $ml \cdot kg^{-1} \cdot min^{-1}$ (21%) using wrist weights. Heart rates also increased 4 bpm when using ankle weights and 13 bpm when using wrist weights. The RER values for using wrist weights were significantly greater than the no weight and ankle weight conditions, but RER was not different between no weight and ankle weights. The RPE values were significantly higher with the use of wrist weights but not ankle weights. Therefore, it was determined that ankle and wrist weights could be effective for increasing exercise intensity in Phase III and IV cardiac patients.

In a study conducted by Graves, Pollock, Montain, Jackson, and O'Keefe (7) it was found that 3 lb hand-held weights could increase the metabolic cost of training. The subjects, which included 12 untrained men, participated in two maximal and three submaximal treadmill tests. Heart rate, oxygen uptake, and RPE were significantly greater with the addition of hand-held weights to walking exercise. Walking with 3 lb weights increased oxygen consumption by approximately 1 MET and heart rate by 7-13 bpm. It was also found that an exaggerated increase in systolic and diastolic blood pressures occurred with the addition of hand-held weights during walking exercise. For this reason, the use of hand-held weights may be most beneficial for those individuals who are healthy and wish to increase the intensity of their walking program. However, hand-held weights may be contraindicated for certain patient populations because of the exaggerated blood pressure response.

Another study done by Graves, Martin, Miltenberger, and Pollock (6) found similar results when using hand-held weights, wrist weights, and ankle weights. The subjects included 12 sedentary men who completed three treadmill tests with 3 lb weights and exercised at 75% of maximal heart rate reserve. Blood pressures and rating of perceived exertion were not significantly different for any of the three kinds of weights.

During walking, the energy cost increased 2.4 $ml \cdot kg^{-1} \cdot min^{-1}$ for ankle weights and 3.8 $ml \cdot kg^{-1} \cdot min^{-1}$ for hand and wrist weights. Heart rates also increased from 147 bpm with no weight to 155-161 bpm with the addition of weights. The RER values were significantly greater with the addition of weights compared to no weights.

<u>Weight Loaded Walking and Stepping</u>

In addition to hand, wrist, and ankle weights, researchers have studied the effects of load carriage closer to the body and not on the extremities. Patton, Kaszuba, Mello, and Reynolds (10) studied the physiological responses to prolonged treadmill walking with external loads of 31.5 and 49.4 kg. The load was carried in a rucksack with an external frame and belt with suspenders. It was concluded that oxygen consumption and heart rate increased significantly during prolonged walking with external loads. When walking with 31.5 kg, VO_2 increased an average of 10% at speeds of 3.0 and 3.6 mph. Similarly, carrying 49.4 kg increased VO_2 by an average of 16% at speeds of 2.5 and 3.6 mph.

Left ventricular responses with prolonged treadmill walking during heavy load carriage were studied by Sagiv, Ben-Sira, Sagiv, Werber, and Rotstein (11). The subjects included well trained healthy males who carried a 38 or 50 kg backpack while walking on a treadmill for 4 hours. It was found that with the 50 kg backpack there were significantly higher values for heart rate, and oxygen uptake compared to the 38 kg backpack. Values for VO_2 increased from 14.3 with the 38 kg backpack to 19.2 ml·kg

$^{1}\cdot min^{-1}$ with the 50 kg backpack. Heart rates also increased from 104 to 128 bpm at the same weight loads. Ratings of perceived exertion did not significantly increase.

Schram and Hanson (12) evaluated the effect of added weight on oxygen consumption and heart rate of 13 male cardiac rehabilitation patients. Each subject walked on a treadmill at 3 mph and 0% grade in five sequential 8 min stages. During the first stage subjects walked without a load and in the following stages weight was added in 5 kg increments until the subject achieved a prescribed training heart rate or completed the fifth stage at 20 kg. It was found that oxygen consumption and heart rate increased without the appearance of dysrhythmias or ischemic electrocardiogram changes. In fact, oxygen consumption and heart rate increased linearly by 1.5 $ml\cdot kg^{-1}\cdot min^{-1}$ and 6-7 bpm at each 5 kg load. A significant increase in rate of perceived exertion was also found at each 5 kg load.

The effects of weight loaded bench stepping has been studied by Stanforth and Stanforth (13). Scuba weights and a belt were used with 2.7, 5.4, and 8.2 kg of added weight. Participants stepped at 120 bpm on three different bench heights. It was found that oxygen consumption increased by 18.6 $ml\cdot min^{-1}$ for each kg of weight added while using the 20.3 cm (8 inch) bench height. At this same bench height, heart rates increased by 5 bpm with the addition of 2.7 kg and by 8 bpm with the addition of 5.4 kg of weight.

<u>Weighted Fitness Vest</u>

Recently a study was conducted by Engels and Wirth (5) to determine the physiological responses to steady-rate level walking while wearing a weighted vest. The subjects included five males and five females who walked on the level at 3 mph for 10 min during each test. The tests were conducted with no weight and with the vest loaded with 5, 10, 15, 20, and 25% of body weight. Values for VO_2, HR, and RPE increased significantly with the weight load increments. The RER values showed no significant differences. The greatest increase in VO_2 occurred while walking with the weighted vest at 25% of body weight, and equaled 1.92 $ml \cdot kg^{-1} \cdot min^{-1}$ (16%). The authors believed that it would be necessary for the vest to be loaded considerably more in order to provide an effective physiological stimulus of any practical significance.

Walcott et al. (14) also studied heart rate and VO_2 responses to level walking with a weighted vest (0, 10, 20, 30, and 40% of body weight) at 3.5 and 4.0 mph. It was reported that oxygen consumption and HR increased significantly for males and females walking at 3.5 and 4.0 mph. Females walking at 3.5 mph showed 8 and 17% increases in VO_2 with the addition of 10 and 20% body weight, respectively. At 4.0 mph there were 11 and 21% increases in VO_2 with the same weights. Heart rates also increased at the same load carriages. From 0 to 10% of body weight, a 5 bpm (4%) increase was found. Overall, the authors concluded that females had a significantly greater response than males did for each speed and load carried. The responses were also significantly greater at 4.0 mph compared to 3.5 mph.

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 several studies hand and ankle weights increased the intensity of walking for trained men as well as cardiac patients (1,2,3,6,7,8,15). Oxygen consumption increased from 7-255% over that of walking without weights. It was determined that generally wrist weights showed greater increases in VO_2 compared to hand weights, and pumping hand weights resulted in the greatest increases. However, running with weights was found to have little or no effect on oxygen consumption (4,9,15). Researchers have also reported significant increases in VO_2 and heart rate with the use of a weighted backpack or similar load carriage (10,11,12). Finally, it was concluded that wearing a weighted vest with level walking can increase oxygen consumption by 8% with the addition of 10% of body weight (14).

REFERENCES

1. Abadie, B.R. Physiological responses to grade walking with wrist and hand-held weights. *Res. Q. Exerc. Sport* 61:93-95, 1990.

2. Amos, K. R., J. P. Porcari, S. R. Bauer, and P. K. Wilson. The safety and effectiveness of walking with ankle weights and wrist weights for patients with cardiac disease. *J. Cardiopulmonary Rehabil.* 12:254-260, 1992.

3. Auble, T. E., L. Schwartz, and R.J. Robertson. Aerobic requirements for moving handweights through various ranges of motion while walking. *Physician Sportsmed.* 15:133-140, 1987.

4. Claremont, A. D. and S. J. Hall. Effects of extremity loading upon energy expenditure and running mechanics. *Med. Sci. Sports Exerc.* 20:167-171, 1988.

5. Engels, H. J. and J. C. Wirth. Physiological responses to steady-rate walking using an adjustable weighted fitness vest. *Res. Q. Exerc. Sport* 67(March Suppl.): A32, 1996.

6. Graves, J. E., A. D. Martin, L. A. Miltenberger, and M. L. Pollock. Physiological responses to walking with hand weights, wrist weights, and ankle weights. *Med. Sci. Sports Exerc.* 20:265-271, 1988.

7. Graves, J. E., M. L. Pollock, S. J. Montain, A. S. Jackson, and J. M. O'Keefe. The effect of hand-held weights on the physiological responses to walking exercise. *Med. Sci. Sports Exerc.* 19:260-265, 1987.

8. Makalous, S.L., J. Araujo, and T.R. Thomas. Energy expenditure during walking with hand weights. *Physician Sportsmed.* 16:139-148, 1988.

9. Martin, P. E. Mechanical and physiological responses to lower extremity loading during running. *Med. Sci. Sports Exerc.* 17:427-433, 1985.

10. Patton, J. F., J. Kaszuba, R. P. Mello, and K. L. Reynolds. Physiological responses to prolonged treadmill walking with external loads. *Eur. J. Appl. Physiol.* 63:89-93, 1991.

11. Sagiv, M., D. Ben-Sira, A. Sagiv, G. Werber, and A. Rotstein. Left ventricular responses during prolonged treadmill walking with heavy load carriage. *Med. Sci. Sports Exerc.* 26:285-288, 1994.

12. Schram, V. and P. Hanson. Cardiovascular and metabolic responses to weight-loaded walking in cardiac rehabilitation patients. *J. Cardiopulmonary Rehabil.* 8:28-32, 1988.

13. Stanforth, P. R. and D. Stanforth. The effect of adding external weight on the aerobic requirement of bench stepping. *Res. Q. Exerc. Sport* 67:469-472, 1996.

14. Walcott, G., R. Coleman, M. MacVeigh, et al. Heart rate and VO_2 response to weighted walking. *Med. Sci. Sports Exerc.* 18:S28, 1986.

15. Zarandona, J. E., A. G. Nelson, R. K. Conlee, and A. G. Fisher. Physiological responses to hand-carried weights. *Physician Sportsmed.* 14:113-120, 1986.