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Training Effects of Adding Resistive Arm Exercise to a Walking Program

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TRAINING EFFECTS OF ADDING RESISTIVE ARM EXERCISE TO A WALKING PROGRAM

By

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ABSTRACT

The dose of exercise required for successful weight loss is greater than the minimum amount of exercise recommended to improve health. Time constraints and risk of musculoskeletal injuries are two factors that make adherence to exercise difficult for the overweight and unfit person. One possible strategy for increasing the rate of caloric expenditure while walking without increasing the duration or intensity of exercise is to include upper-body exercise. We have found that using resistive arm exercise (waist belt with pull cords) raises energy expenditure by approximately 30% while walking. **PURPOSE:** The purpose of this study was to determine whether adding arm exercise while walking during an 8-week walking program would result in greater reductions in BMI and percent body fat (%BF) and an increase in $\dot{V}O_2$max of overweight adults when compared to walking without arm exercise. **METHODS:** Twenty four participants (age: 39 ± 10 yr; mean ± SD) were randomly assigned to an experimental group (arm exercise + walking) and a control group (walking only). Training sessions were 30-50 min, 3-5 d/wk, progressing in duration and frequency over 8 wks. Walking intensity was set slightly below lactate threshold. **RESULTS:** Arm exercise was performed on average 61 % of the time during the training sessions. While training improved $\dot{V}O_2$max (30.5 ± 5.8 to 33.5 ± 7.0 vs 29.0 ± 5.8 to 32.1 ± 5.3 $ml \cdot kg^{-1} \cdot min^{-1}$) and reduced BMI (28.2 ± 2.1 to 27.9 ± 2.5 vs 29.9 ± 2.9 to 29.7 ± 3.1 $kg \cdot m^{-2}$) and %BF (30.7 ± 6.2 to 28.9 ± 6.5 vs 30.9 ± 6.9 to 30.2 ± 7.2) similarly in experimental and control groups ($p < 0.05$), respectively, there were no differences in group responses. **CONCLUSION:** The addition of resistive arm exercise to walking did not result in significant improvements in $\dot{V}O_2$max, BMI or

%BF despite the increased rate of energy expenditure during training. *Partially supported by Walker's Warehouse, Tequesta, FL.*

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CHAPTER ONE

INTRODUCTION

Walking is a common form of exercise for many people and is becoming increasingly popular among American adults (53). However, more than 60 percent of American adults are not regularly active and 25 percent of the adult population are not active at all (39). Therefore, it is imperative to find new ways of motivating American adults to exercise since physical inactivity is associated with chronic diseases, such as heart disease and diabetes (7, 27).

As a popular form of physical activity, low-to-moderate intensity walking has a relatively high adherence rate (8) that likely is due to fewer unpleasant sensations associated with exercise (46). In addition, low-to-moderate intensity walking is an excellent exercise mode for unfit and overweight individuals who want to improve their cardiorespiratory fitness and lose fat mass.

Even if no reduction in fat mass is observed during a moderate-intensity exercise program, factors associated with cardiovascular disease are minimized (57). In addition, walking, which is the most common weight-bearing activity, can improve bone strength and insulin sensitivity, enhance the immune system response to infections, lower blood pressure and peripheral resistance as well as improve self-perception and minimize depression (37).

Improvements in cardiovascular fitness can even be observed in overweight people walking in multiple 5-minute bouts throughout the day. Coleman et al. (8) found no significant differences ($p > 0.05$) in improvements of cardiovascular fitness when participants opted to walk 30 minutes continuously or in multiple bouts of 5, 10 or 15 minutes. This makes walking an excellent mode of training for unfit individuals or overweight people who cannot engage in high-intensity activities for long periods at a time.

Despite the cardiorespiratory fitness benefits of low-to-moderate intensity exercise, research has shown that to reduce fat mass significantly, overweight individuals must exercise at relatively high training volumes and for long periods of time in order to expend the necessary number of calories (15, 29, 50). For instance, Coleman et al. (8) found that a 16-week moderate intensity walking program was sufficient to significantly ($p \leq 0.05$) improve cardiovascular fitness but not enough to decrease percent body fat (%BF) of overweight individuals. However, a 32-week follow up in this same study revealed a significant ($p \leq 0.05$) decrease in %BF regardless of the intervention groups participants were in. It may be that the 16-week walking program was not sufficient in duration to elicit reductions in %BF when moderate-intensity walking was prescribed.

Jakicic et al. (20) determined that the minimum recommended 150 minutes per week of training, a public health recommendation (39), is not sufficient to elicit a significant reduction in body weight. The greatest magnitude of weight loss was observed when participants engaged in low-to-moderate exercise activity for more than 280 minutes per week. Therefore, exercise duration and frequency must be increased above the recommended 150 min/week when significant ($p \leq 0.05$) reduction in body mass (BM) is the primary goal.

In support of this, Klem et al. (23) found that participants who lost weight and maintained the loss for 5 years were expending on average 2827 kcal/week through physical activity; this caloric expenditure is more than the minimum value of 1000 kcal/week recommended for public health (39). Clearly, if the greatest magnitude in weight loss or weight maintenance is expected, training volume and intensity should be increased with the purpose of achieving a caloric expenditure beyond that supported by current public health recommendations.

However, high-intensity exercise may be counterproductive for sedentary, overweight, and unfit people in terms of musculoskeletal injuries and adherence. For instance, exercising at high intensity too soon in the exercise program can increase the incidence of acute injuries in the lower leg, such as shin splints (10). High-intensity activities such as jogging or running are also associated with higher self-perceived effort; this could negatively affect exercise adherence. As an alternative, increasing energy expenditure during exercise without increasing intensity to such levels that could cause musculoskeletal injuries can be accomplished by adding an upper-body workout during walking.

Adding an upper-body workout while walking may facilitate individuals in expending calories at a higher rate without having to increase the walking or jogging pace. Graves et al. (13) found that during exercise at 60 and 75% of maximal oxygen uptake ($\dot{V}O_2max$), the addition of 3-lb hand weights increased the energy cost of walking by approximately 1 MET. These investigators also found that pumping the arms substantially can increase the energy cost of walking. Auble et al. (2) determined that $\dot{V}O_2$ was almost 25% greater when 3-lb hand weights were used at an arm pumping height of 0.61 m than when walking normally.

Regarding the use of walking poles, Rodgers et al. (48) determined that the total caloric expenditure while walking with walking poles (174 kcal) was significantly greater ($p \leq 0.05$) than that achieved while walking without walking poles (141 kcal) during 30 minutes of exercise at 4.2 mph and 0% grade. In addition, Nurge et al. (41) found that the energy expenditure while using an Aerobelt™ (a waist-worn belt with tubing type resistance for the arms) was 54% greater than when walking without the use of the Aerobelt™. Moreover, Zedaker et al. (60) determined that $\dot{V}O_2$ and heart rate (HR) increased 64% above normal walking values when using a Powerbelt™ (a waist-worn belt with resistance cords for the arms) with cord resistance set at three (on a scale of 1 to 4).

It should be noted that with any exercise program, training adaptations are primarily specific to the musculature trained. This effect has been regarded as the principle of specificity (33). Research has shown that the transfer effects of training are limited when the untrained limb is tested after the other limb has been trained. That is, investigators have studied, for example, whether or not there is any transfer of training from the arms to the legs after the arms are trained for a period of time (30, 38, 54). $\dot{V}O_2$max during leg exercise is tested before and after the training program to determine if the arm exercise program caused an increase in oxygen consumption in the untrained musculature.

Mostardi et al. (38) reported that following eight weeks of exercise training no significant ($p > 0.05$) differences in $\dot{V}O_2$max were seen between arm-and-leg-cycle-trained, performed conjunctly, and leg-cycle-trained groups. In other words, the authors found that adding an upper body workout to leg cycling did not result in a significant increase in $\dot{V}O_2$max. Thus, no transfer effects of training were seen from the arms to the legs. The lack of effect could be due to the fact that training workloads, based on $\dot{V}O_2$max and HRmax, were the same for the groups, with the workload being divided between legs and arms in the leg-arm group. In fact, the authors reported that the arm and leg exercise was easier to perform than the leg-only exercise. If the arm-leg group had trained at a higher workload (identical leg workloads in the 2 groups) $\dot{V}O_2$max may have increased to a greater extent.

Two studies have seen training effects occurring from the trained to the untrained limb after a training program (30, 54). For instance, even though Loftin et al. (30) determined that the largest increases in $\dot{V}O_2$max occurred for the musculature that was specifically trained (arms), improvements in $\dot{V}O_2$max were also observed when participants were leg tested ($p < 0.05$). Therefore, a transfer effect of training may have occurred from the arms, which were trained for 5 weeks, to the legs. The reason for the transfer effect may have been cardiovascular in nature. Central physiological and metabolic adaptations to exercise may likely occur when the upper-body workout is added to walking. Stroke volume (SV) was determined to be the primary central adaptation to exercise training because no differences in maximal HR were observed (30).

Tordi et al. (54) reported transfer effects of training on the ventilatory threshold (VT) from the arms to the legs and vice versa after a 6-week training period. The $\dot{V}O_2$ at VT in the leg-trained group increased significantly ($p < 0.05$) from 15 to 21 ml/kg/min from pre to post arm-testing. Likewise, the $\dot{V}O_2$ at VT in the arm-trained group increased significantly ($p < 0.05$) from 28 to 34 ml/kg/min from pre to post leg- testing.

An increase in SV may have been a major factor when finding a transfer effect of training from the arms to the legs.

There are several potential benefits of adding arm exercise to a walking or running exercise program. An obvious benefit of adding arm exercise to walking is the increase in the rate of caloric expenditure without increasing the relative intensity of the lower-body exercise component. Adding arm exercise to a walking program may not only provide additional fitness and health benefits, but also it may enhance exercise adherence since less effort may be perceived when exercising with a greater proportion of the musculature.

Adding an upper-body workout to walking would improve the cardiorespiratory and muscular endurance in the upper body compared to walking only. Karawan et al. (22) indicated that upper-body muscular endurance significantly increased 34% ($p < 0.05$) when walking with poles following a 12-week exercise program. Muscular endurance was assessed by performing 1-min bouts of alternating arm pulls on a modified isokinetic swimbench apparatus.

The combination of walking with upper-body exercise can serve as a warm-up period for the lower body as well as the upper body prior to lifting weights. The combination of a walking with upper-body exercise program can be attractive to those individuals with tight schedules and time constraints, providing them both upper and lower body conditioning. Coleman et al. (8) indicated that it was easier for his participants to walk during the work week than during the weekends because the time demands during the weekends were less predictable.

Furthermore, adding upper-body exercise while walking could have a positive effect in the clinical setting, specifically in cardiac rehabilitation programs, because clients could exercise at a lower relative intensity (relative to leg exercise $\dot{V}O_2$peak) while involving a greater muscle mass. Walter et al. (56) found that phase III/IV cardiac rehabilitation patients significantly increased ($p < 0.05$) the energy cost of walking by 21% (3.8 ml/kg/min) while walking with poles compared to walking without poles, without affecting the safety of the exercise program. Adding walking poles to walking may improve the stability for people with lower-extremity orthopedic or balance problems (48).

Finally, the combination of walking and upper-body exercise may benefit the elderly who are affected by sarcopenia which is characterized by muscle tissue loss as a result of diminished muscle mass and strength (32). An experimental study revealed that, after 12 weeks of strength-training conducted with older women between 68 and 79 years old, strength and whole muscle size increased (11). Similarly, a study on physical function in older inner-city African-American women demonstrated that upper-body strength increased by 24% after 4 weeks of training using the combination of elastic bands and dumbbells (49). The involvement of the upper body in exercise is especially important to improve the functional capacity of older individuals during activities of daily living (ADL). Landers et al. (26) found that no difference in difficulty was observed between younger and older women during the carry task after the covariate arm lean tissue was added to the model. That is, when the biceps muscle group of women who had gained lean muscle mass in the elbow flexors as a result of strength training was tested isometrically, no significant difference during the carry task was observed between the younger and older women. Therefore, the investigators showed that strength training of the elbow flexors in older women improved their performance in upper body-related physical tasks of daily living.

Statement of the Problem

To my knowledge there was no data available comparing the metabolic and physiological training adaptations between the use of arm resistance exercise while walking and walking alone. In light of the potential benefits, it was necessary to study the physiological and metabolic effects of an exercise training program that included upper-body resistance exercise while walking.

The independent variable of this study was the exercise training either walking alone or walking with use of a Powerbelt™. The Powerbelt™, similar to a weight belt, is worn around the waist and has resistance cords with handles. The resistance can be adjusted to four different levels using PowerPak™ units from which the resistance cords are pulled. The dependent variables of this study were the maximum oxygen consumption ($\dot{V}O_2max$) measured during walking or running, lactate threshold (LT), relative body fat level (%BF), body mass index (BMI), body mass (BM), ventilation at maximal exertion ($\dot{V}_e$ max), respiratory exchange ratio (RER), rating of perceived exertion (RPE), as well as maximal heart rate (HRmax). The categorical variables of this study were the gender and age of participants. There were two extraneous variables which were not controlled in this study: diet and exercise outside the training study. However, participants were instructed to not be involved in any type of physical training and to keep the same eating pattern throughout the training study. The participants´

training time as well as the days of training was not totally controlled due to individual schedules.

Purpose of the Study

The purpose of this study was to determine whether adding arm exercise while walking during an 8-week treadmill walking regimen would result in greater increases in $\dot{V}O_2$max and a greater reduction in BMI, BM, and %BF of overweight adults when compared to walking without arm exercise.

Significance of the Study

In view of the fact that walking is one of the most popular physical activities for Americans (53), that limited time is dedicated to exercise, and that two thirds of the American adult population are overweight, the results from this training study may demonstrate the benefits of combined arm and leg exercise for those wanting to exercise for weight loss. If greater training benefits are demonstrated following eight weeks of combined upper-body exercise and walking, it could become a popular mode of physical activity for many more overweight individuals.

Hypotheses

It was hypothesized that $\dot{V}O_2$max would improve to a greater extent following eight weeks of a combined Powerbelt™-with-walking program compared to a walking only program. It was also hypothesized that %BF would decrease significantly ($p < 0.05$) following the training program in participants randomly assigned to the Powerbelt™

group compared to those randomly assigned to the walking-only group. Furthermore, it was expected that BMI would decrease significantly ($p < 0.05$) following the Powerbelt™-with-walking program compared to a walking-only program. Finally, it was hypothesized that BM would decrease significantly ($p < 0.05$) after the combined Powerbelt™-walking program when compared to the walking-only program.

Operational Definitions

For the purposes of this study, terms were defined as follows.

Absolute submaximal exercise intensity refers to a specific exercise intensity below maximum aerobic power. Absolute intensity is expressed as mph and grade (treadmill walking or running), kcalories/min, or $\dot{V}O_2$. It was used to set the initial training intensity of participants and was adjusted as participants´ fitness improved during the study.

Ataxia refers to dizziness associated with an increase in nervous system activity (1).

Body mass index (BMI) is the ratio of body weight in kilograms to height in meters squared.

Continuous exercise refers to performing a pre-established spacing of exercise without rest intervals.

Cyanosis is skin discoloration and refers to a sign poor perfusion (1).

Heart rate reserve (HRR) is the difference between maximal heart rate (HRmax) and resting heart rate (RHR).

High-intensity exercise refers to exercising above OBLA, at a RPE of approximately 15 to 17, and between 76 and 90% of $\dot{V}O_2$max.

Hypertensive response refers to a systolic blood pressure (SBP) of more than 250 mmHg and/or a diastolic blood pressure (DBP) of more than 115 mm Hg (1) during exercise.

Insulin sensitivity refers to the ability of the skeletal muscle to take in blood glucose at a given insulin concentration (33). People suffering from Type II diabetes usually manifest poor insulin sensitivity since glucose uptake by skeletal muscle is impaired for a given insulin concentration.

Intermittent exercise or interval exercise refers to performing exercise in pre-established spacing of exercise and rest intervals (33).

Lactate threshold (LT), expressed as percent age of $\dot{V}O_2$max, refers to the exercise intensity occurring before OBLA during incremental exercise (52). The intensity below which metabolic processes are predominantly aerobic.

Low-intensity exercise refers to exercising below the lactate threshold, between 30 and 50% of VO_{2max}, and at a RPE of approximately 11 to 12.

Maximum oxygen consumption ($\dot{V}O_2$max) refers to the maximum capacity of the cardiorespiratory system to deliver oxygen to the working muscles combined with the ability of skeletal muscles to use that oxygen. An increase in $\dot{V}O_2$max is the most valid method of demonstrating an aerobic training effect (24).

Metabolic adaptation refers to the improved capacity of the respiratory control in skeletal muscle as a result of aerobic training (33). Aerobic training leads to an improved capacity to oxidize fat molecules for energy production. Improved enzymatic activity, increased number and size of mitochondria, and increased capillary density are some of the metabolic adaptations which improve the reliance of O_2 processes leading to an improved muscular respiration.

Metabolic equivalents (METs) are defined as multiples of the resting metabolic rate and are usually utilized to classify the intensity of leisure-time physical activities (33). For instance, 1 MET equals the resting oxygen consumption (3.5 ml/kg/min) and 3 METs equals three times the resting level.

Metabolic load refers to an increase in respiratory work at the muscular level with the reliance of non oxygen processes to supply energy. This metabolic load is caused by an increase in exercise intensity and/or the use of a specific muscle group leading to local fatigue.

Moderate-intensity exercise refers to exercising at or slightly above the lactate threshold, but just below the onset of blood lactate accumulation (OBLA), at a RPE of approximately 13 to 14, and from 51 to 75% of $\dot{V}O_2$max.

Peak oxygen consumption ($\dot{V}O_2$peak) refers to the highest $\dot{V}O_2$ value measured during a graded exercise test when leveling off does not occur or test performance is limited by local muscular factors (33).

Physiologic adaptation refers to cardiovascular and peripheral adaptations caused by aerobic training. An increased delivery of O_2 to the exercising muscle is one of the major central adaptations. An increase in muscle fiber size is a peripheral physiologic adaptation.

Pressor reflex response refers to the disproportionate rise in HR and blood pressure (BP) relative to $\dot{V}O_2$ during exercise (59).

Rating of perceived exertion (RPE) refers to the participant's perception of how exhausted or fatigued he or she is during continuous exercise. The Borg's rating scale (6-20) was used in this study (4).

Relative body fat (%BF) refers to the percentage of body fat with respect to total body mass. For this study, %BF was estimated from the calculation of body density, which in turn was estimated by skinfold thickness measurements.

Relative submaximal exercise intensity refers to an exercise intensity below maximum intensity corresponding to a percent age of $\dot{V}O_2$max.

Respiratory exchange ratio (RER) refers to the ratio of carbon dioxide produced to oxygen consumed (33). It is used to indicate whether carbohydrates or lipids are the primary fuel source during exercise.

Resting metabolic rate (RMR) refers to the sum of all the metabolic processes required to maintain normal body functions at rest (33).

Type II diabetes is a metabolic disease which refers primarily to the inability of the body to respond properly to insulin and the resistance of the skeletal muscle to the actions of insulin (33).

Type IIa muscle fibers show a fast shortening speed and are capable of using energy from both aerobic and anaerobic sources (33).

Type IIb muscle fibers exhibit the most rapid shortening velocity and rely on energy from anaerobic processes (33).

Assumptions

It was assumed that participants would respond truthfully to the health screening questionnaire. Likewise, it was assumed that participants would not undertake another type of exercise and would not change their eating patterns during the training period. Furthermore, it was assumed that participants would give their best effort in $\dot{V}O_2max$ testing trials and all exercise sessions. It was assumed that participants would honestly reflect their level of perceived exertion when asked to so indicate using the Borg scale. Finally, it was assumed that there would be no gender differences in the training responses.

Limitations

The main limitation of this study was that physiological changes induced from eight weeks of exercise training would be less when compared to a longer training period. The sample of this study consisted only of young- and middle-age adults who fell into the low- and moderate-risk categories for cardiovascular events and musculoskeletal injuries, as determined from the health screening. Participants were limited to men and women between the ages of 18-55 years and having a BMI of at least 25 but no greater than 29.9 (overweight category).

Delimitations

In terms of cardiovascular and metabolic adaptations to training, only $\dot{V}O_2max$, LT, and HR responses to exercise were measured in this study. This study did not determine changes in blood pressure due to training. No musculoskeletal or hormonal adaptations to exercise training were measured in this study. The upper-body resistance training exercises consisted of shoulder and elbow extension and flexion using Powerbelts™. Treadmill walking consisted of both level and graded walking with no option to utilize the handrail for support.

CHAPTER TWO

REVIEW OF LITERATURE

Walking is a common form of exercise for many people and is becoming increasingly popular among American adults (53). However, more than 60 percent of American adults are not regularly active and 25 percent of the adult population are not active at all (39). Therefore, it is imperative to find new ways of motivating American adults to exercise since physical inactivity is associated with chronic diseases such as heart disease and diabetes (7, 27).

The purpose of this study was to determine whether adding arm exercise while walking during an 8-week walking regimen would result in greater increases in $\dot{V}O_2max$ and a greater reduction in BMI, BM, and %BF of overweight adults when compared to walking without arm exercise.

It was hypothesized that $\dot{V}O_2max$ would significantly improve to a greater extent following eight weeks of a combined Powerbelt™-with-walking training program compared to a walking only program. It was also hypothesized that %BF would decrease significantly ($p < 0.05$) following the training program in participants randomly assigned to the Powerbelt™ group compared to those randomly assigned to the walking-only group. Furthermore, it was expected that BMI would decrease significantly ($p < 0.05$) following the Powerbelt™-with-walking training program compared to a walking only program. Finally, it was hypothesized that BM would decrease significantly ($p < 0.05$) after the combined Powerbelt™-walking training program when compared to the walking-only program.

Walking and Improved Cardiovascular and Metabolic Fitness

Walking is one of the most common and natural physical activities which can be sustained by everyone except for the seriously disabled or very frail (37). Several studies have shown that light-to-moderate intensity walking improves cardiovascular fitness and provides an array of health benefits, including reduced body fat (16, 24, 28, 29, 37, 42, 47, 51).

Schmidt et al. (51) determined that $\dot{V}O_2$max increased significantly ($p \leq 0.05$) from baseline to post-treatment in three exercise groups: 30-min daily continuous exercise group with one bout lasting 30 min (1 x 30 min); a 30-min daily accumulated exercise group with two bouts, each lasting 15 min (2 x 15); and a second 30-min accumulated exercise group with three bouts, each lasting 10 min (3 x 10). As shown, the benefits of exercise can occur even if the exercise program is broken up into separate time periods throughout the day. Regardless of the number of bouts performed during the day or if the walking bout was continuous or intermittent, $\dot{V}O_2$max was significantly greater ($p \leq 0.05$) when compared to baseline values.

Helmrich et al. (16) determined that leisure-time physical activity, expressed in kcal per week in walking, was inversely related to the development of Type II diabetes in a descriptive study conducted on 5990 male alumni. The investigators found that the incidence rates declined as energy expenditure increased from less than 500 kcal to 3500 kcal per week. Therefore, the minimum public recommendation of 1000 kcal in caloric expenditure per week (39) could positively protect against the development of Type II diabetes. The authors also found that the greatest protective effects of regular walking was strongest in individuals at highest risk for Type II diabetes such as those having a high body-mass index, a history of hypertension, or family history of diabetes.

Regarding the susceptibility of postmenopausal women for developing osteoporosis, Krall and Dawson-Hughes (24) determined that healthy postmenopausal women who walked approximately one mile each day had higher whole-body bone density than women who walked shorter distances. The sample consisted of 239 healthy, white, postmenopausal women who participated in a 1-year, placebo-controlled trial of vitamin D supplementation. The investigators also found that walking was effective in slowing the rate of bone loss from the legs.

More benefits of walking were found by Parkkari et al. (42) who determined that regular walking during a golf game positively affected body composition including reductions in: BM, waist circumference, and abdominal skinfold thickness measurements. The sample consisted of 55 healthy male golfers who had been sedentary during the seven months before the study. The authors also found that golfers had significantly greater ($p < 0.05$) increases in serum high-density lipoprotein (HDL) cholesterol levels and in the ratio of HDL cholesterol to total cholesterol. Therefore, regular walking may guard against the development of several positive risk factors for cardiovascular disease.

In summary, walking is a viable exercise for improving not only cardiovascular fitness and body composition, but it is also appropriate for inducing protective health safeguards against chronic diseases such as diabetes, osteoporosis, and coronary artery disease.

Walking and Weight Loss

The National Center for Chronic Disease Prevention and Health Promotion and the Surgeon General's Report on Physical Activity and Health have recommended that 30 minutes of brisk walking on most days of the week is sufficient to elicit health improvements (39). However, a review article by Jakicic and Gallagher (19) revealed that 60 minutes, as opposed to only 30 minutes, of daily activity at moderate intensity was associated with the greatest magnitude of weight loss. These findings by Jakicic and Gallagher (19) are consistent with those of Kraus et al. (25) who found that increasing exercise duration is more effective than increasing exercise intensity when weight reduction is the goal.

Jakicic et al. (20) determined that the minimum recommended training duration of 150 minutes per week (39) was not sufficient to elicit a significant reduction in BM. The greatest magnitude of weight loss was observed when participants engaged in exercise activity for more than 280 minutes per week. Therefore, exercise duration and frequency must be increased above the recommended level of physical activity (150 min/week) when significant weight loss is the goal.

In support, Klem et al. (23) found that participants who lost weight and maintained the loss for 5 years were expending on average 2827 kcal/week through physical activity; this is significantly more than the minimum public health recommended value of 1000 kcal/week (39). Clearly, if the greatest magnitude in weight loss or weight maintenance is expected, training volume and intensity should be increased with the purpose of achieving a caloric expenditure beyond that supported by current public health recommendations.

Associated with the benefits of exercise for fat loss are the possible effects on increased fat oxidation. Van Aggel-Leijssen et al. (55) found that exercise training at high intensity does not significantly increase ($p > 0.05$) total fat oxidation during a moderate-intensity exercise session. They stated that exercise training in obese men is effective in increasing total fat oxidation when exercise training is executed at low intensity (40% $\dot{V}O_2max$). Fat oxidation at rest was significantly decreased ($p < 0.05$) in the high-intensity (70% $\dot{V}O_2max$) training group after 12 weeks of training. Therefore, to optimally promote fat oxidation, which in turn promotes fat mobilization from adipose tissue and consequently reduced body fat, high-intensity exercise need not be performed.

However, some studies have shown that for a significant reduction in body weight to occur, the exercise intensity should be high, at least 70% $\dot{V}O_2max$ (29, 50). Leon et al. (29) found a 5.9 kg decrease in body fat and a decrease in %BF from 23.3 to 17.4 % in 6 sedentary obese men (ages 19 to 31 years) after they completed 16 weeks of vigorous walking. The training program consisted of 90 minutes of treadmill walking at speeds up to 3.2 mph at a 10% grade, 5 days per week. The authors reported that participants expended approximately 1100 kcal per session. Likewise, Ross et al. (50) indicated that the body weight of 12 obese men decreased 7.5kg or 8% of total body weight ($p < 0.001$) after 12 weeks of daily brisk walking or light jogging at a duration and intensity high enough to expend 700 kcal/session. It is conceivable that a training program of high intensity and long duration may cause greater reductions in body weight when compared to a moderate exercise program consisting of brisk walking for 30 minutes. However, the practicality of such vigorous programs to reduce body weight in the sedentary population is ineffective in view of the fact that the incidence of lower-leg injuries and attrition rate will likely be higher than that in less vigorous programs (10).

In addition to increasing caloric expenditure, a moderate-intensity aerobic training program, such as walking, can also increase the resting metabolic rate (RMR). Lennon et al. (28) determined that RMR increased by 4% from baseline values in the group that performed 30 minutes of daily self-selected aerobic activity. It has been determined that RMR is affected by body composition; an increase in lean body mass has been linked to an increase in RMR (33). Therefore, weight loss programs should emphasize an increase in lean body mass through exercise in order to increase the RMR of an individual. This in turn will cause an individual to expend more calories at rest which would contribute to the attainment of a negative energy state.

In summary, the duration and frequency, but not intensity, of exercise training should be higher than that recommended by public health authorities (39). These recommendations are primarily focused on health benefits, with the purpose of observing the greatest magnitude of weight loss.

Arm vs. Leg Exercise: Acute Responses

The quantity of muscle recruited plays a prominent role in acute physiological responses during exercise. $\dot{V}O_2max$ during arm exercise is approximately 70% of that obtained during leg exercise, and $\dot{V}O_2max$ during treadmill walking is about 10% higher compared to $\dot{V}O_2max$ during maximal exercise on the cycle ergometer (35, 40). However, research has shown that when adding arm exercise to leg exercise, the increase in $\dot{V}O_2$max is not significant (14). This emphasizes that the CV response to exercise, or oxygen delivery to muscle, limits $\dot{V}O_2$peak.

Gutin et al. (14) found that adding arms to leg work during an incremental protocol did not lead to a higher $\dot{V}O_2$peak when compared to legs alone in 10 nonsmoking men with a mean age of 31 years. The incremental protocol was performed separately with the arms, legs, and both combined. However, during constant load exercise participants could tolerate the workout better when arms were added to the leg work in comparison to working with the legs only. When arm and leg exercise were combined during a constant load routine, the power output was divided in such a way that some participants performed arm work at 10% and others at 25% of the total power output. It was suggested that arm and leg training might be especially valuable for weight control and cardiorespiratory conditioning. If individuals better tolerate a workout when arms are added to leg training, greater caloric expenditure may occur given that participants could exercise for a longer period of time without feeling the demands associated with the metabolic load.

Regarding HR responses to upper- and lower-body exercise, Jensen-Urstad et al. (21) determined that HR was higher (161 bpm) at the end of 20-min of leg cycling than at the end of arm cycling (150 bpm) in 7 physically active men. The workloads corresponded to 59 and 60% of $\dot{V}O_2$peak during leg and arm cycling, respectively. Comparable to this finding, but in terms of maximal heart rate (HRmax), Miles et al. (35) found that HRmax was significantly higher ($p < 0.05$) by 5 bpm, on average, during treadmill walking when compared to cycle ergometer. It can be noted that the higher HR were observed in the exercise modes that involved more muscle mass. Localized fatigue may have been a limiting factor during arm exercise and cycle ergometry, thus limiting HR response and $\dot{V}O_2$peak or $\dot{V}O_2$max.

Total blood flow for the exercising extremity was also found to be significantly lower during arm ergometry when compared to cycle ergometry (21). Total blood flow can be interpreted as total cardiac output; cardiac output is the product of stroke volume and heart rate and represents the volume of blood pumped by the heart in one minute. Therefore, a lower stroke volume or heart rate may result in a lower blood flow to the exercising musculature. HRmax was previously reported to be lower during arm exercise (21). There could be an association between a lower HRmax during arm exercise and the lower total blood flow to the arm musculature compared to the leg musculature.

It is interesting to note that despite the lower limb volume, arterial blood lactate was higher during arm exercise than during leg exercise (21). The authors found that the arterial-mixed-venous difference for lactate was more than three times higher during arm exercise than during leg exercise. The authors suggested that the difference in metabolic response between arm and leg exercise may, to some extent, be explained by the influence of the legs being more trained than the arms. In other words, a trained muscle group will rely more on oxidative processes to provide energy for the exercising muscles. Thus, the accumulation of blood lactate, which is an end product of anaerobic glycolysis, will be lower in trained muscles. Also, trained muscles will likely have more Type IIa fibers, which are more oxidative than Type IIb fibers.

Pimental et al. (43) found that at the same absolute intensity, blood lactate response was significantly greater ($p < 0.05$) during upper- compared to lower-body exercise, but at the same relative intensity lactate values were similar during lower- and upper-body exercise. The authors suggested that lactate responses during prolonged upper- and lower-body exercise are dependent on relative exercise intensity rather than the size of the muscle groups employed.

Similar to this finding, Miles et al. (35) found that blood lactate concentrations and RER were higher during cycle ergometer exercise than during treadmill walking. In addition, plasma pH and bicarbonate concentration were lower following exercise on the cycle ergometer compared to the treadmill during both submaximal and maximal exercise. They concluded that the difference in lactate response may have been caused by the difference in muscle mass utilized. A smaller muscle mass is recruited during cycle ergometer exercise as compared to treadmill exercise.

Perceived exertion was not taken into consideration in these two investigations of the acute physiological and metabolic responses to arm and leg exercise (21, 35). Had perceived exertion been taken into account, exercises involving less muscle mass may have been rated more strenuous than exercises involving greater muscle mass at any given absolute intensity. There seems to be an association between high RER, lactate concentrations, and higher ratings of perceived exertion (RPE).

In conclusion, physiological acute responses vary according to the amount of muscle mass recruited during exercise. Smaller muscle mass (arms) showed lower peak $\dot{V}O_2$peak and HR values and greater blood lactate concentration and RER values than larger muscle mass (legs).

Arm vs. Leg Exercise: Cross-Training Effects

The transfer effects of exercise training from one muscle group to another have been a point of debate in the research community, with the central focus regarding whether or not central or peripheral adaptations are transferred to the non-trained muscles. When $\dot{V}O_2$peak or $\dot{V}O_2$max was assessed after a training program, one study reported no transfer effects from one muscle group to another (3); another study found a transfer effect to the lower body when an upper-body endurance program was added (30). A third study found a transfer effect to the upper body when a lower-body endurance training program was added (54).

The purpose of the study of Bhambhani et al. (3) was to determine whether endurance training in the form of arm or leg cycling resulted in significant transfer effects when exercise was performed with the untrained musculature. Their sample consisted of 20 middle-age male adults who were divided into two separate training groups: arm cycling or leg cycling. Training intensity was set mid-way between the ventilatory threshold (VT) and $\dot{V}O_2$peak obtained separately from arm and leg maximal ergometry tests. For the arm group, exercise training corresponded to 72% of their $\dot{V}O_2$peak while for the leg group it was approximately 80%. Each training session lasted 30 min. Participants completed 24 supervised exercise sessions over an 8-week period, generally 3 times/week on alternate days. A transfer effect of training from one muscle group to the other was not evident at either $\dot{V}O_2$peak. That is, arm cycle training had no significant influence on the peak physiological responses observed during leg cycling, and leg cycle training had no significant influence on the peak physiological responses during arm cycling. The investigators also reported no training adaptations from one muscle group to the other at VT.

On the other hand, Loftin et al. (30) found a transfer effect when the arm-only group was tested during peak leg exercise, thus showing a transfer effect from the upper- to the lower-body. The purpose of this study was to examine the effect of endurance arm training on metabolic and circulatory function during arm and leg ergometry exercise. The sample consisted of 38 women who were assigned to either an experimental (n =19) or control (n =19) group. The control group did not participate in any type of training while the experimental group was involved in arm training. The arm training program consisted of 5 weeks of training, 4 days per week, for a total of 20 sessions. Participants exercised for six, 4-minute bouts, with each work period separated by a 2-min pause. The investigators found a 32% increase in $\dot{V}O_2$ during peak arm exercise after arm training in the arm-only exercise group while $\dot{V}O_2$ increased 7% during leg testing, suggesting some training adaptations in the lower body after arm training. The predominant effect of arm training may have been to improve the central circulatory function to support $\dot{V}O_2$max during leg exercise.

In contrast, Tordi et al. (54) found a training response in the upper body following a lower-body endurance training program. The sample consisted of 15 physically-active males with a mean age of 23 years. Before and after 6 weeks of the training program, all subjects were evaluated on two separate days on the wheelchair and leg-cycle ergometer. The subjects were divided into three groups with matched physical characteristics and initial performances: untrained-control (n = 5), arm-trained (n = 5), and leg-trained (n = 5) groups. Arm and leg training consisted of 3 SWEET (Square Wave Endurance

Exercise Test) sessions per week performed during 6 weeks. One session consisted of 9 consecutive periods of 5 minutes with a workload equivalent to VT followed by 1-min peak work. The intensity for the arm group and leg group was increased by steps of 10 W and 30 W, respectively, when the HR registered at the end of the session was at least 10 bpm lower than the highest HR of the previous sessions. The arm group showed a significantly higher ($p < 0.01$) percentage change in arm-ergometer $\dot{V}O_2$peak compared to pre-training. Similarly, the leg group showed a significantly higher ($p < 0.01$) percentage change in leg-ergometer $\dot{V}O_2$peak compared to pre-training. Even though the leg-trained group significantly ($p < 0.05$) improved peak work output (+11%) in arm ergometry, no improvement in leg peak work output was found in the arm-trained group. In other words, a training effect was observed from the legs to the arms but not vice versa.

The investigators suggested that the transfer effect from the legs to the arms occurred because leg training fully taxed the cardiovascular system as a result of greater muscle mass involvement and higher HR values than during arm training. Therefore, greater central adaptations seem to occur in exercises involving a greater muscle mass. If this viewpoint is taken into consideration, no transfer effects should be observed from the arms to the legs due to the smaller muscle mass involved during arm training. However, a transfer effect for both the lower body and upper body was observed when participants were tested at their VT after the training program. A 46% increase in $\dot{V}O_2$ at VT was observed in the arm-trained group during leg testing while a 22% increase in $\dot{V}O_2$ at VT occurred in the leg-trained group during arm testing.

Based on previous research, it can be concluded that transfer effects of training can be observed from the upper-body to the lower-body musculature through central CV adaptations such as an increased cardiac output. Peripheral adaptations, such as changes in muscle fiber type and increases in oxidative enzymes in the muscle, may possibly play an important role in the transfer effects of training. It is important to remark that training volume and intensity have to be high enough to elicit changes in cardiorespiratory fitness.

Physiological Effects of Combining Arm and Leg Exercise

Several studies have reported that adding hand or wrist weights to walking causes increases in $\dot{V}O_2$ and HR when compared to walking without weights at the same pace (2, 12, 13, 31, 36, 59). In addition, other studies have determined that adding an upper-body workout to walking by using walking poles (45, 48, 56) dual-action treadmill (treadmill with upper-body handles) (6), and an Aerobelt™ (waist belt with tubing-type resistance for the arms) or a Powerbelt™ (waist belt with resistance cords for the arms) (18, 41, 60) increases $\dot{V}O_2$ and HR in comparison to normal walking. Among these studies, however, the magnitude of increases varied according to the amount of resistance applied, arm motions, walking speed, and subject characteristics.

Zarandona et al. (59) demonstrated that walking with a 5-lb weight in each hand caused a significant increase ($p < 0.05$) in $\dot{V}O_2$ and HR, compared with carrying no weights or a 1-lb weight in each hand. A 17% increase in $\dot{V}O_2$ occurred when walking with 5-lb hand weights compared to walking with 1-lb hand weights or no weights. Regarding HR, a 15% increase was observed when walking with 5-lb hand weights compared to walking with 1-lb hand weights or no weights. The sample consisted of 30 trained male runners and joggers with a mean age of 29 years. Participants walked on a treadmill at 3.5 mph using an arm motion consisting of bringing the hand weights up in an exaggerated swing to 90 degrees from the body and then straight down beside the body. The investigators indicated that, to elicit a major increase in metabolic cost, the load must be about 5 lb in each hand. But hand or wrist weights in excess of 3 pounds are not typically recommended because they cannot be used continuously for a significant length of time (44).

Similarly, Graves et al. (13) reported increases in $\dot{V}O_2$ and HR during submaximal walking with 3-lb hand weights compared to walking with 1-lb hand weights or no weights. The sample consisted of 12 untrained men with a mean age of 31 years. The participants were instructed to hold the hand weights loosely, to lift them to shoulder height on each arm swing, and to achieve a 90 degree angle at the elbow when the hand weights were at shoulder height. The physiological responses were determined when participants walked submaximally at 60 and 75% HR reserve (HRR). At 60% HRR $\dot{V}O_2$ increased about 5% and 12% with 3-lb hand weights (28.6 ml/kg/min) compared to walking with 1-lb hand weight (27.2 ml/kg/min) or normal walking (25.3 ml/kg/min), respectively. A similar trend was observed when walking at 75% HRR. Walking with 3-lb hand weights at 60% HRR increased HR by 13 bpm (155 bpm) compared to walking without weights (142 bpm). However, the difference in HR between walking with a 3-lb hand weight and walking only decreased as the intensity of walking increased. At 75% HRR, the increase in HR was 8 bpm. Interestingly, no differences in $\dot{V}O_2$ and HR during maximal testing were reported. Additionally, a significant increase ($p \leq 0.01$) in ventilation during submaximal walking with 3-lb hand weights compared to walking with

1-lb hand weight or no weight was reported. However, no significant differences ($p > 0.05$) in peak ventilation between maximal treadmill exercise with 3-lb hand weights and without weights were observed. Lack of differences during maximal testing was likely caused by a bigger contribution of arm movement during unweighted maximal treadmill exercise.

Auble et al. (2) determined that the increase in $\dot{V}O_2$ when hand weights were added to walking was affected by walking speed, amount of handheld weight, level of hand weight elevation, and frequency of leg stride as well as arm motion. Nine physically active men with a mean age of 28 years were instructed to walk on a treadmill with and without hand weights at a 0% grade at speeds of 2.5, 3.0, 3.5, and 4.0 mph. During weighted walking, participants used 1-, 2-, and 3-lb hand weights that were strapped across the back of the hand. The heavier the hand weight used during walking, the greater the increase in $\dot{V}O_2$ at any given speed. For example, when using 3-lb hand weights with an arm elevation of 1.07 m, $\dot{V}O_2$ increased (42 ml/kg/min) compared to walking with 2-lb hand weights (36 ml/kg/min), 1-lb hand weights (31 ml/kg/min) and no weights (25 ml/kg/min) at 3.5 mph. Participants were also instructed to swing their arms upward with 0.15-m increments from 0.61 to 1.07 m high. The higher the hand weights were raised, the greater the $\dot{V}O_2$. For instance, when walking with 2-lb hand weights and at 1.79 m/130leg-stride and arm-motion frequency, $\dot{V}O_2$ was higher with an arm elevation of 1.07 m (43 ml/kg/min) compared to an arm elevation of 0.91 m (34 ml/kg/min), 0.76 m (32 ml/kg/min), and 0.61 m (28 ml/kg/min). The authors also determined that as the leg-stride and arm-motion frequency increased, $\dot{V}O_2$ increased at a given walking pace. The investigators indicated that the reason for the high variability in energy expenditure was due to the amount of arm movement used by participants instead of the resistance of the hand weights. These findings are supported by Porcari (44), who found that the 50-75% increase in $\dot{V}O_2$ and caloric expenditure comes from just swinging the arms to a greater degree. In addition, Makalous et al. (31) reported that pumping the arms with no hand weights can substantially increase the energy cost of walking.

Makalous et al. (31) showed that walking with 1-lb hand weights elicited significantly higher ($p < 0.05$) HR than normal walking or walking with exaggerated arm exercise during 30 minutes of walking at 3.4 mph and 0% grade. In addition, the investigators found that walking with 1-lb hand weights caused a significant increase ($p < 0.05$) in $\dot{V}O_2$ compared to normal walking during 30 minutes of walking at 3.4 mph and 0% grade. The sample consisted of 3 obese men and 8 obese women with a mean age of 34 years. Participants were instructed to pump the arms rhythmically, starting with the arms straight at the sides and moving the hands up to waist level with a 90 degree angle at the elbow. The mean HR for walking with 1-lb hand weight was 127 bpm, which was 7% greater than normal walking (120 bpm) and 3% above normal walking with exaggerated arm exercise (123 bpm). HR did not differ between normal walking and exaggerated-arm exercise walking. The $\dot{V}O_2$ for walking with 1-lb hand weight was 1.168 L/min, 7% greater than normal walking (1.086 L/min). The $\dot{V}O_2$ response for exaggerated-arm exercise walking was not different ($p > 0.05$) from walking with 1-lb hand weights or normal walking.

Graves et al. (12) determined that $\dot{V}O_2$ and HR were significantly greater ($p < 0.01$) during walking with hand and wrist weights than during walking with no weights. The sample consisted of 12 sedentary men with a mean age of 20 years. Participants walked with no weights, with 3-lb hand weights, and with 3-lb wrist weights. The subjects were instructed to use a relaxed grip on the weights. The arm movement consisted of lifting the weights to shoulder height and maintaining a 90 degree bend in the elbow throughout the range of motion. The average treadmill speed was at 3.9 mph, and the grade corresponded with a HR of 75% HRR. Heart rates were significantly greater ($p < 0.01$) during exercise with hand weights (161 bpm) and wrist weights (160 bpm) than during exercise with no weights (146 bpm). No differences existed in HR between walking with hand weights and walking with wrist weights. $\dot{V}O_2$ was significantly greater ($p < 0.01$) during walking with both hand and wrist weights (30 ml/kg/min) than during walking with no weights (26 ml/kg/min). The investigators also determined that ventilation was significantly greater ($p < 0.01$) during walking with hand and wrist weights than during walking with no weights.

Miller and Stamford (36) reported a significant difference ($p < 0.05$) in $\dot{V}O_2$ between walking with 5-lb hand weights and no weights in healthy men and women. Participants walked at 2, 3, or 4 mph carrying no weights or 5-lb hand weights. The walking sessions were performed in 10-minute bouts followed by a rest period of at least 10 min. Participants were instructed to move the hand weights from approximately the umbilicus to the sternoclavicular joint. Participants were allowed to straighten their arms briefly in order to relax the arm muscles and reduce localized fatigue. At 2 mph, $\dot{V}O_2$ increased 44% during walking with 5-lb hand weights (13 ml/kg/min) compared to walking with no weights (7.3 ml/kg/min). At 3 mph, a 40% increase in $\dot{V}O_2$ was observed during walking with 5-lb hand weights (17.7 ml/kg/min) compared to walking with no weights (10.6 ml/kg/min). At 4 mph, $\dot{V}O_2$ increased 26% during walking with 5-

lb hand weights (25.1 ml/kg/min) compared to walking with no weights (18.7 ml/kg/min). It can be noted that the percent increase in $\dot{V}O_2$ between conditions decreased as speed was increased, similar to what Graves et al. (13) found. The contribution of arm movement during walking with no weights at higher speeds may have contributed to the lower percentage change in $\dot{V}O_2$. The energy cost of walking with hand weights was significantly greater ($p < 0.05$) than normal walking. For example, the energy cost of walking at 4 mph was 9 kcal/min with 5-lb hand weights and 7 kcal/min without weights. It is important to note that the investigators reported no differences in energy cost between genders during both walking with and without weights at any speed.

Pertaining to the studies that indicated increases in $\dot{V}O_2$ and HR when adding walking poles to the activity of walking, Rodgers et al. (48) determined that the average $\dot{V}O_2$ for the total 30 min exercise period was significantly greater ($p \leq 0.05$) when walking with poles (20.5 ml/kg/min) than when walking without them (18.3 ml/kg/min). In terms of caloric expenditure, the increase in $\dot{V}O_2$ during walking with poles was equivalent to 173.7 kcal/session compared to only 140.7 kcal/session during walking without poles. Participants completed two randomly assigned trials of treadmill walking at 4.2 mph at 0% grade for 30 min with and without walking poles. The average weight of each of the walking poles was 13 – 14 ounces. The poles were gripped, planted, and swung through. In addition, the average HR of 132 bpm achieved over the total 30 min period of walking with poles was significantly greater ($p \leq 0.05$) than the average HR of 121 bpm achieved during walking without the poles. The authors indicated that the movement of the treadmill belt may have contributed to the work of moving the pole across the ground. Therefore, it was concluded that a greater increase in $\dot{V}O_2$ and HR could have been observed had the participants walked on pavement.

Porcari et al. (45) also showed that $\dot{V}O_2$ and HR were significantly higher ($p < 0.05$) during walking with poles than during walking without poles. When walking with poles, HR increased by 15 bpm for men and 21 bpm for women. The authors reported that exercise intensity increased from 58% of HRmax during walking without poles to 67% of HRmax during walking with poles. The sample consisted of 16 men and 16 women. Participants completed two 20-minute submaximal walking trials on a level treadmill with and without walking poles. The men walked at an average of 4.3 mph and the women walked at an average of 3.8 mph. In this study, the walking poles were heavier (1 lb) when compared to the previous study.

A significant difference in HR ($p < 0.05$) was also determined in phase III and IV cardiac rehabilitation patients when they walked with walking poles. Walter et al. (56) reported that HR significantly increased ($p < 0.05$) by 14 bpm in this clinical population when participants walked on a level treadmill with walking poles in comparison to walking without poles. The investigators determined that walking with poles increased the energy cost of walking by 21% (3.8 ml/kg/min) compared to walking without poles.

Using a dual-action treadmill, Butts et al. (6) determined that $\dot{V}O_2$ and HR were significantly greater ($p < 0.001$) during arm activity in a dual-motion treadmill than during walking only. When participants incorporated the arm movement, set at the highest resistance, there was an average increase in the metabolic costs of approximately 55%. During walking with arm activity versus without at 2.0, 3.0 and 4.0 mph, $\dot{V}O_2$ and HR increased 36% and 15%, 37% and 19% and 32% and 20%, respectively. For example, at 4 mph the mean $\dot{V}O_2$ for men walking with the use of the arms (35.8 ml/kg/min) was significantly greater ($p < 0.001$) than walking without arm motion (24 ml/kg/min). At the same speed, mean HR for women walking with the use of the arms (156 bpm) was significantly greater ($p < 0.001$) than walking without arm motion (124 bpm).

In a study that determined increases in $\dot{V}O_2$ and HR when adding an Aerobelt™ or Powerbelt™ to walking, Nurge et al. (41) indicated that the difference in $\dot{V}O_2$ and HR between Aerobelt™ walking and normal walking was 52% and 34%, respectively. Participants walked at an intensity above 50% $\dot{V}O_2max$ with and without an Aerobelt™ on a treadmill at approximately 4.20 mph. Alternating arm motions were used every second stride during aerobelt walking.

Hopkins et al. (18) found that $\dot{V}O_2$ and HR were significantly greater ($p < 0.01$) in two different walking protocols involving Aerobelt™ when compared to normal walking, in both men and women. Participants engaged in normal walking and two Aerobelt™ walking protocols on a treadmill at 4 mph. One Aerobelt™ walking protocol consisted of raising each arm to a shoulder flexion of 90 degrees every stride while the other was based on a simulated cross-country skiing action at each stride. $\dot{V}O_2$ and HR were significantly greater ($p < 0.01$) in the cross-country skiing Aerobelt™ protocol when compared to the 90-degree shoulder flexion Aerobelt™ protocol. In Aerobelt™ walking, when participants raised each arm to a shoulder flexion of 90 degrees $\dot{V}O_2$ increased 30% in comparison to normal walking. When participants simulated a cross-country skiing action using the Aerobelt™ $\dot{V}O_2$ increased 52% in comparison to normal walking. Raising each arm to a shoulder flexion of 90 degrees with the Aerobelt™

yielded an intensity level of 56% of $\dot{V}O_2max$ compared to 67% $\dot{V}O_2max$ when simulating a cross-country skiing action, and 42% $\dot{V}O_2max$ during normal walking.

Zedaker et al. (60) reported that $\dot{V}O_2$ and HR increased when Powerbelt™ (similar to the Aerobelt™) usage was added to walking in comparison to normal walking. The sample consisted of 6 males and 6 females between the ages of 20 and 50 years. Participants completed six trials of normal walking, walking with raised arms, walking with the base unit of the Powerbelt™, and walking at increased resistance levels 1 to 3 of the Powerbelt™. Each trial lasted 3 min with 3-minute rest between conditions. $\dot{V}O_2$ for normal walking and walking with raised arms was 14.9 ml/kg/min and 17.7 ml/kg/min, respectively (an 18.8% increase). In addition, HR during normal walking and walking with raised arms was 101 bpm and 110 bpm, respectively. As the resistance of the Powerbelt™ increased, increases in $\dot{V}O_2$ and HR were seen in comparison to normal walking. $\dot{V}O_2$ while walking with the base unit of the Powerbelt™ and with increased resistance levels 1, 2 and 3 of the Powerbelt™ was 21.2 ml/kg/min, 21.7 ml/kg/min, 22.9 ml/kg/min, and 24.4 ml/kg/min, respectively. HR for the same conditions was 128 bpm, 133 bpm, 137 bpm, and 145 bpm, respectively. On the other hand, $\dot{V}O_2$ and HR during normal walking were 14.9 ml/kg/min and 101 bpm, respectively. When compared to normal walking, $\dot{V}O_2$ and HR increased about 39% and 30% during resistance 3 of the Powerbelt™. It is important to mention that the authors also found an increase in $\dot{V}O_2$ and HR during walking with raised arms in comparison to normal walking. The increase in $\dot{V}O_2$ and HR during walking with raised arms was less than that during walking with the Powerbelt™ at resistance levels 1, 2, and 3.

The physiological responses described in the previous studies were obtained during submaximal testing. Therefore, peak responses in $\dot{V}O_2$ and HR to walking with the addition of weights or walking with the involvement of the upper-body musculature could not be determined from such studies. However, one of the previous studies did measure $\dot{V}O_2$peak during walking with 3-lb hand weights, 1-lb hand weights and no weights (13). No significant differences in $\dot{V}O_2$peak between maximal treadmill exercise with and without 3-lb hand weights were found. This may be because the arm movement seen at high intensities of walking or running is exaggerated compared to lower intensities. This finding is supported by Graves et al. (13) and Miller and Stamford (36), who reported that the percent difference in $\dot{V}O_2$ between walking with 5-lb hand weights and no weights decreased as speed was increased. Thus, the reduced difference in $\dot{V}O_2$ between walking with 5-lb hand weights and no weights at higher speeds may be the consequence of greater contribution of the arms during fast walking with no weights.

In addition, the results of a study by Bryant et al. (5) were consistent with those obtained in the previous study. They reported no significant differences in $\dot{V}O_2$peak and HRpeak during maximal uphill treadmill running and maximal uphill treadmill walking while pumping 3-lb hand weights. The sample consisted of 16 physically active men. However, when participants performed a maximal treadmill walking test with 2-lb hand weights at a level grade, their $\dot{V}O_2$peak and HRpeak were significantly lower ($p < 0.01$) compared to that of maximal uphill walking with 3-lb hand weights. Both the effects of uphill walking and the use of heavier hand weights may have caused participants to attain higher $\dot{V}O_2$peak values. However, this conclusion could be misleading based on the fact that one variable could have only caused an increase in $\dot{V}O_2$peak.

Regarding the respiratory exchange ratio (RER), two studies reported significant differences in RER between walking with hand weights and normal walking (12, 13). Graves et al. (13) found that RER was significantly greater ($p \leq 0.01$) during walking with a 3-lb hand weight (0.95) than during walking with 1-lb hand weight (0.93) or no weight (0.93) at 60% HRR. A similar increase in RER was found during walking with a 3-lb hand weight (0.96) in comparison to walking with 1-lb hand weight (0.95) or no weight (0.94) at 75% HRR. Similar to these findings, Bryant et al. (5) found significant differences ($p < 0.01$) in RER between maximal uphill treadmill walking while pumping 3-lb hand weights (1.14) and the maximal level-grade treadmill walking while pumping 2-lb hand weights (1.07).

Similarly, Graves et al. (12) found that the RER during walking with hand weights (0.91) and wrist weights (0.91) was significantly greater ($p < 0.01$) than the RER observed during walking with no weights (0.88) at an average speed of 3.91 mph and grade of 6.3%. However, the investigators found no differences in RER between walking with hand weights and walking with wrist weights.

In studying the effects of walking with walking poles, Rodgers et al. (48) found that RER was significantly greater ($p \leq 0.05$) when walking with poles (0.82) compared to normal walking (0.78). Moreover, Porcari et al. (45) indicated that the RER values were significantly higher ($p < 0.05$) for both men and women when exercising with poles (0.93) in comparison to normal walking (0.85).

On the other hand, Makalous et al. (31) found no significant differences in RER values during exercise and recovery between normal walking, exaggerated arm exercise walking, and walking with 1-lb hand weights. Comparable to these findings, Graves et al.

(13) found no differences in RER values between maximal treadmill exercise with 3-lb hand weights and no weights even though, as it was previously reported, they reported significant differences ($p \leq 0.01$) between these two conditions during submaximal exercise. And no differences in RER were reported between uphill treadmill running and uphill treadmill walking while pumping 3-lb hand weights (5). Similar to the previous findings, but with the involvement of a dual-action treadmill, Butts et al. (6) found no differences in RER between walking with arm action and walking only on a dual-action treadmill at any of the walking speeds.

In reference to ratings of perceived exertion (RPE), Graves et al. (13) found that the RPE was significantly greater ($p \leq 0.01$) during walking with a 3-lb hand weight (13.0) than during walking with 1-lb hand weight (11.3) or no weight (11.7) at 60% HRR. At 75% HRR RPE was significantly greater ($p \leq 0.01$) during walking with a 3-lb hand weight (14.3) than during walking with 1-lb hand weight (13.3) or no weight (13.3). Porcari et al. (45) indicated that both men and women had significant increases ($p < 0.05$) in their average RPE when walking with the poles (11.9) compared to walking without poles (10.4). Moreover, Butts et al. (6) reported that RPE was significantly greater ($p < 0.001$) for both men and women when walking with arm action than when walking only in a dual-action treadmill. For example, at 4 mph the average RPE was 13.0 when walking with arm action compared to 11.65 while walking only. In addition, Nurge et al. (41) indicated a mean RPE that was significantly greater ($p < 0.01$) during Aerobelt™ walking (13.5) when compared to normal walking (10.2). Similar to these findings, Hopkins et al. (18) found significant differences ($p < 0.05$) in average RPE values between two Aerobelt™ protocols -raising each arm to a shoulder flexion of 90 degrees

(12.9) and simulating a cross-country skiing action (13.4)- and normal walking (10.5). However, the authors did not find significant differences ($p > 0.05$) in RPE between the two Aerobelt™ walking protocols.

In contrast, Graves et al. (12) saw no differences in RPE during walking with no weights, with hand weights and with wrist weights. The investigators reported that RPE between the three conditions ranged from 13 to 14. The lack of differences in RPE may have been the result of greater than expected level of upper-body fitness which may have not been taxed enough by using 3-lb hand weights and wrist weights. Furthermore, Rodgers et al. (48) found that RPE was not different between walking with walking poles and walking without them. The investigators reported that participants were moderately active which may have produced a previous adaptation to upper-body exercise. Also, the use of walking poles on the treadmill may have impeded further stimulation of the upper-body musculature due to the natural motion of the treadmill belt in pulling the walking poles back as they made contact on the belt.

Clearly, $\dot{V}O_2$ and HR increase when adding arm exercise to leg exercise. The magnitude of the increase depends on the arm exercise mode, arm movement, amount of resistance, and walking speed. Taking the mean of the percent increases in $\dot{V}O_2$ from the 13 studies previously described in relation to walking with added weight and normal walking, an increase of 30% in $\dot{V}O_2$ occurred when an upper-body workout was added to walking. In regard to HR, the mean of the percent increase from nine previously mentioned studies was 18% between adding an upper-body workout to walking and normal walking. However, these percent increases in $\dot{V}O_2$ and HR are estimates considering that the amount of resistance, the walking speed and the arm movement varied among studies as did the mode of exercise.

Training with Combined Arm and Leg Exercise

To my knowledge, only one training study exists investigating the effects of walking with arm exercise. Karawan et al. (22) found a significant increase ($p < 0.05$) of 34% in muscular endurance from pretest values when walking with poles compared to a 14% increase ($p > 0.05$) from the pretest following a walking-only program. The sample consisted of 92 inactive females with an age range of 20-59 years. Participants were randomly assigned to one of three groups: walking with poles, walking without poles, and controls. The training program consisted of a 12-week walking program, 4 days per week, for 30-45 min per session, at 70-85% of HRmax. Muscular endurance was assessed before and after the training period by directing participants to alternatively perform arm pulls on a modified isokinetic machine. Total work output was used as the criterion measure. Even though the authors indicated an increase in muscular endurance in the group that walked with poles, there were no increases in pushdown or pulldown strength for the walking-with-poles group. It is important to mention that this study is one of a few that have determined the training effects of adding an upper-body workout to walking. Unfortunately, aerobic capacity or other cardiovascular fitness variables were not measured, so it is uncertain whether walking with poles imparts greater improvements in cardiovascular fitness.

Mostardi et al. (38) investigated whether leg exercise in the form of cycling had a comparable training effect to that associated with arm and leg exercise in the form of arm ergometry and leg cycling, respectively. The sample consisted of 11 healthy men who were randomly assigned to an arm and leg group (n = 6) or a leg group (n = 5). For the arm and leg group, the training program consisted of a 6-week arm and leg cycling protocol at 30% and 70%, respectively, of the absolute workload of legs alone. The investigators found that regardless of the amount of muscle mass recruited in the training program, the levels of acquired conditioning were equal. The arm-and-leg trained group and leg trained group had a 13.5% and 13.3% increase in $\dot{V}O_2$max during a maximal leg test after the training period. The absolute $\dot{V}O_2$ values before and after training for the arm-and-leg trained group were 39.2 ml/kg/min and 44.5 ml/kg/min, respectively. The absolute $\dot{V}O_2$ values for the leg group before and after training were 41.3 ml/kg/min and 46.8 ml/kg/min, respectively. It is important to remark that no training effects occurred during maximal leg testing after conditioning the arms and legs because the workloads were similar for both conditions. That is, the relative workload for the arm and leg group was the same (30% and 70%, respectively) as that of the leg group (100%). Had the leg workload in both groups been the same, a training effect would have likely occurred in the legs when tested maximally because a greater overall workload would have been achieved by adding arm exercise, thus providing a greater cardiovascular training stimulus.

Leg $\dot{V}O_2$max following arm and leg training when leg workload is controlled has not yet been tested. A greater increase in $\dot{V}O_2$max during maximal leg testing may occur after training the arms and legs due to central cardiovascular adaptations as result of arm and leg training. In summary, limited current data exists regarding the transfer effects of training from a trained limb to an untrained limb. Future studies should be conducted to determine which training adaptation (central vs. peripheral) to aerobic training is most influential which would consequently affect the current interpretation of cross training.

Safety Issues Concerning Combined Arm and Leg Exercise Training

Concerning the safety of these forms of exercise, changes in blood pressure are of special consideration when an isometric component (e.g. holding hand weights) is added to dynamic exercise or when the upper body is continuously involved in resistance exercise. Several studies showed an increase in systolic blood pressure (SBP) when hand weights (12, 13, 59) and walking poles (56) were added to walking.

It should be noted that upper-body exercise alone will cause a higher heart rate and a lower stroke volume when compared to lower body exercise (34). However, stroke volume will improve as a consequence of a training regime consisting of upper-body exercise. Thus, a higher volume of blood will be delivered with each heart beat, demonstrating the positive effects of upper-body exercise training. However, when adding upper-body resistance training for people suspected or diagnosed as having high blood pressure, caution should be taken regarding the weight of the resistance. Walking while carrying 3- or 5-lb hand weights results in a greater SBP response compared to walking without hand weights or using 1-lb hand weights (12, 13, 59). Likewise, SBP increased 16 mmHg in phase III and IV cardiac rehabilitation patients when walking with poles in comparison to normal walking (56). In contrast, Porcari (44) did not report an exaggerated blood pressure response when walking poles were added to walking.

Some studies indicated that a pressor reflex response was not caused by the isometric component of holding the hand weights (2, 59) and walking poles (56) during walking. Zarandona et al. (59) showed that oxygen pulse ($\dot{V}O_2$/HR) did not decrease while walking with 5-lb weights. They contended that if the pressor reflex had been initiated, HR would have increased disproportionately to the metabolic need of the body with a subsequent decrease in oxygen pulse. Similarly, Auble et al. (2) concluded that holding the hand weights while pumping the arms did not elicit an excessive pressor response given the normal relationship they observed between $\dot{V}O_2$ and HR. It is important to point out that a pressor reflex response may not have been observed because the hand weights were strapped to the participant's hands, thus reducing the isometric component to dynamic exercise. Comparable to the previous findings, Walter et al. (56) found that changes in HR were consistent with the increase in $\dot{V}O_2$ when walking poles were added to walking in phase III and IV cardiac rehabilitation patients. Thus, these normal changes in HR and $\dot{V}O_2$ were not related to a pressor response mechanism. However, as noted earlier, there was a 16 mmHg increase in SBP for cardiac patients when walking with poles.

Regarding changes in diastolic blood pressure (DBP) when hand weights were added to walking, Graves et al. (13) determined that the average DBP was greater during walking with a 3-lb hand weight (80.5 and 78.1 mmHg) than during walking with 1-lb hand weight (77.7 and 74.6 mmHg) or no weight (75.2 and 73 mmHg) at 60% and 75% HRR, respectively. Similarly, Graves et al. (12) saw an average increase in DBP of 4.4 mmHg during walking with hand weights compared to walking with no weights. No differences in DBP responses were observed between walking with hand weights and wrist weights. Furthermore, Walter et al. (56) indicated that an increase in DBP (4 mmHg) occurred when walking poles were added to normal walking for phase III and IV cardiac rehabilitation patients.

Concerning the injury risk when adding hand or wrist weights to walking, three studies (2, 13, 36) mentioned the potential risks involved when adding hand weights. Miller and Stamford (36) reported an increased risk of elbow tendonitis (tennis elbow) when using hand weights. That is why Rodgers et al. (48) have recommended the use of walking poles during walking in place of hand or wrist weights because walking poles are lighter than most hand weights and the incidence of overuse injuries would be much less. The authors also contended that walking poles could be utilized during walking to increase stability for people with lower-extremity orthopedic problems.

On the other hand, Graves et al. (13) cautioned the use of hand weights when walking for people who are hypertensive or who are suspected of being hypertensive. They pointed out that people who are hypertensive, have a hypertensive response to exercise, or have a diminished functional reserve may be negatively affected by an isometric pressure overload which is likely caused by the hand-gripping action from holding the hand weights. In these circumstances, the use of wrist weights could substantially reduce the risk of an isometric response.

In addition, Auble et al. (2) mentioned that an increased clinical risk existed in persons with cardiovascular disease when a static component was added to dynamic exercise. They based their assertions on the grounds that an accentuated pressor response, likely caused by the hand-gripping action of the hand weights, increases myocardial oxygen demand without a corresponding increase in total body aerobic metabolic rate.

It is also important to mention that walking with hand or wrist weights probably eliminates the higher foot-strike forces and potential for lower extremity injuries inherent in running without sacrificing exercise intensity (2). Similar to this viewpoint, walking poles can decrease the stress placed on the lower extremities because a portion of the body weight is supported by the poles (44). Willson et al. (58) determined that the use of walking poles tended to reduce the vertical joint reaction forces at the knee over the no pole condition. They found that stresses on the lower extremity were reduced even though there was a faster walking velocity when using the walking poles.

In regard to walking with poles, there seems to be only one consideration for avoiding any potential injury. In view of the fact that using walking poles requires a greater amount of shoulder swing and back muscle involvement (45), strains on the shoulder rotator-cuff muscles as well as strains and spasms on the back musculature could be considered potential injuries.

Pertaining to the use of the Powerbelt™, Porcari (44) cautioned that its use could elicit exaggerated blood pressure responses due to the high degree of muscular effort. The investigator also recommended that higher resistance levels may be too difficult to maintain, except for highly-fit individuals.

Summary

Walking is an excellent exercise mode for programs emphasizing health-related goals and weight loss because the lower training volume and intensity observed during walking allow individuals to attain such goals without increasing the incidence of overuse injuries and negatively impacting exercise adherence. Adding arm exercise to walking could be an alternative to walking alone in terms of increasing energy expenditure without the need to increase the exercise intensity to a point of jogging or running. In addition, cardiovascular fitness may be improved when arm exercise is added to walking; arm exercise while walking has been shown to elicit greater increases in $\dot{V}O_2$ and HR compared to walking only.

CHAPTER THREE

METHODS

The purpose of this study was to determine whether adding arm exercise while walking during an 8-week walking regimen would result in greater increases in $\dot{V}O_2$max and a greater reduction in BMI, BM, and %BF of overweight adults when compared to walking without arm exercise.

It was hypothesized that $\dot{V}O_2$max would improve to a greater extent following eight weeks of a combined Powerbelt™-with-walking training program compared to a walking only program. It was also hypothesized that %BF would decrease significantly ($p < 0.05$) following the training program for participants randomly assigned to the Powerbelt™ group compared to those randomly assigned to the walking-only group. Furthermore, it was expected that BMI would decrease significantly ($p < 0.05$) following the Powerbelt™-with-walking training program compared to a walking only program. Finally, it was hypothesized that BM would decrease significantly ($p < 0.05$) after the combined Powerbelt™-walking training program when compared to the walking-only program.

Participants

Thirty five participants were recruited from students, faculty, and staff of the Barry University community. Prior to beginning the study, all participants completed an informed consent form approved by the Barry University Institutional Review Board.

A medical history questionnaire was administered to each participant and resting blood pressure (BP) measurements were taken in accordance with the American College of Sports Medicine's guidelines. Only those individuals deemed low- (asymptomatic; men < 45 yr, women < 55 yr; fewer than 2 cardiovascular disease (CVD) risk factors) or moderate-risk (asymptomatic; men ≥ 45 yr, women ≥ 55 yr; and/or 2 or more CVD risk factors) category were allowed to participate (1). High-risk individuals (having a known cardiopulmonary or metabolic disease, or signs or symptoms of disease) and those having any medical contraindication to exercise were excluded from the study. Only those individuals with a BMI greater than 25 but lower than 30 were included in this study.

Participants were randomly assigned to either a control or experimental group. Participants in the control group trained by walking on a treadmill without the Powerbelt™. In addition to walking on a treadmill, participants in the experimental group exercised their upper-body musculature using the Powerbelt™.

Measurements

Before and after training each of the following variables were measured.

Maximum Oxygen Consumption ($\dot{V}O_2max$*).* Open-circuit spirometry, (Parvo Medics TrueOne® 2400 metabolic cart), was used to measure $\dot{V}O_2max$, RER and minute ventilation ($\dot{V}_e$) continuously. The analyzer was calibrated according to manufacturer guidelines prior to testing. A motor-driven treadmill (Quinton SR-60) was utilized to test participants before and after the training period. The Borg scale (6-20) was used to determine RPE during each stage.

A graded protocol was implemented to assess $\dot{V}O_2max$. The test consisted of 3-min stages until lactate threshold (LT) was attained. Subsequently, the duration of the stages was decreased to 2 min. At the beginning of each stage the treadmill speed and/or grade was adjusted accordingly. Participants walked and/or ran until volitional fatigue was reached; this was the point at which the test was terminated. The criteria for the determination of $\dot{V}O_2max$ were: leveling off of $\dot{V}O_2$ with less than 2.1 ml/kg/min difference between stages, or RER greater than 1.15 and HR_{max} with 10 bpm of predicted HR_{max} (40). HR was measured continuously using a 4-lead ECG (low-risk participants) or 12-lead ECG (moderate-risk participants). Additionally, blood pressure was monitored at each stage for moderate-risk participants.

The test was stopped if any signs or symptoms such as chest pain, signs of poor perfusion (lightheadedness, confusion, ataxia, pallor, cyanosis, nausea, or cold and clammy hands), failure of heart rate to increase with increased intensity, a drop in SBP $\geq$ 20 mmHg with increasing intensity, SBP $\geq$ 260 mmHg, participant request to stop, and/or physical or verbal manifestation of severe fatigue were present. A physician was on-hand for all tests performed with moderate-risk participants. An automatic emergency defibrillator (AED) was on-hand for all tests.

Lactate Threshold (LT). A portable lactate analyzer (Accusport) was utilized to analyze the blood lactate levels of participants. A lancet device (Softclix, Accu-Chek) with sterile lancets was used to puncture the participant’s finger for blood sampling. Blood lactate measurements (mMol) were taken during the last minute of each stage of the graded protocol until LT was reached. Once the participant’s LT was determined, no additional blood samples were taken. LT was determined independently and expressed in absolute (mMol) and relative (% $\dot{V}O_2$max) terms. The blood lactate concentration observed before there was a rapid increase in the accumulation of lactate (OBLA) was regarded as absolute LT. The criterion of 1 mMol difference between stages was utilized for identifying LT. The OBLA criterion of 4 mMol was utilized for identifying LT in participants who did not show a 1 mMol difference between stages.

Percent Body Fat (%BF). A skinfold thickness caliper (Harpenden) was used to measure skinfold thickness at the following sites: chest, abdomen and thigh for males and triceps, suprailiac, and thigh for females. Body density was determined by using generalized equations specific to gender and race (17). From body density, percent body fat was determined using specific equations based on gender and race (17).

Body Mass Index (BMI). To calculate BMI, the BM of participants was measured in pounds by using a balance beam scale (precise to 0.2 lb) and then converted to kilograms by dividing the weight in pounds by 2.2. The height of participants was measured in centimeters by using a wall-mounted stadiometer (precise to 0.1cm) and converted to meters. BMI is BM/height^2. BM was measured weekly during the training period.

Training

Each participant walked 30-50 minutes 3-5 days/week. Treadmill speed was individualized according to the pretest $\dot{V}O_2$max session on the motor-driven treadmill.

Absolute intensity was set at the speed and grade associated with LT. The training intensity, frequency and duration for the experimental group were the same as for the control group. The training program lasted 8 weeks. Participants exercised 3 times per week the first month; while in the second month they exercised 4-5 times per week. The duration of each exercise session was 30 minutes initially, but was gradually increased to 50 minutes over the 8-week period.

Participants in the control group walked without arm resistance and were asked to not excessively swing their arms. In conjunction with walking, participants in the experimental group used a Powerbelt™ to perform alternated elbow and shoulder flexion and extension at full range of motion (ROM). A Powerbelt™ is composed of an adjustable weight and several PowerPaks™ containing resistance cords. The PowerPaks™ are installed on the posterior part of the Powerbelt™ and the resistance cords will come out from the PowerPaks™ dorsilaterally on the body. The PowerPaks™ start with a resistance of 1 and can be adjusted in increments of 1 up to 4. Elbow extension consisted of moving the arm forward and upward (concentric contraction) against a specific resistance set by the Powerpaks™. Elbow flexion basically consisted of the arm coming back to its original position by eccentrically countering the resistance of the cords. Basically, the arm movement was similar to that used during cross-country skiing. While walking, the treatment group participants engaged in the arm movement for as long as the tempo could be maintained. A tempo was sustained at a rate similar to leg stride frequency. At this time, they retracted the resistance cords and continued walking for a short period of time (1-2 min) before beginning the arm exercise again. HR and RPE were recorded and assessed during the training phase, and intensity of walking and arm resistance increased progressively in accordance with HR and RPE during the eight weeks. Food and fluid intake were recorded weekly to assure that participants complied with their initial dietary intake.

Statistical Analysis

Six independent-samples t-tests were performed to compare baseline measurements of maximum oxygen consumption ($\dot{V}O_2$max), maximum heart rate (HRmax), percent of oxygen consumption at the lactate threshold (%$\dot{V}O_2$max at LT), oxygen consumption at the lactate threshold ($\dot{V}O_2$ at LT), percent of body fat (%BF), and body mass index (BMI) between the drop-out group and the group that completed the study. A 2x2 mixed-design ANOVA was used to determine group differences (Powerbelt™ and walking-only) in HR and RPE responses during training sessions for week 1 and week 8. A one-way repeated measures ANOVA was calculated comparing the absolute time using the Powerbelt™ during the training sessions at three different times: week 1, week 5, and week 8. Regarding the training effects, a 2 x 2 mixed-design ANOVA was performed on each of the dependent variables. A significant interaction was interpreted to mean differences in training effects between arm and leg training and leg-only training. Finally, to test the reliability of skinfold thickness measures, an independent-samples t-test was performed on 11 participants comparing the mean sum of skinfold measurements from two separate occasions. The significance level for all analyses was set at $p < 0.05$. The SigmaStat® 3.0 package was utilized to run the statistics.

CHAPTER FOUR

RESULTS

Pilot Testing

A pilot test involving three participants was conducted before the present study began. Participants walked on a treadmill at 3.5 mph for 5 min with and without the Powerbelt™. A 24% increase in $\dot{V}O_2$ was observed when participants used resistance 1 of the Powerbelt™ compared to walking only. When using resistance 2 of the Powerbelt™, $\dot{V}O_2$ increased 32% compared to walking only.

Demographic Data

There were no significant differences ($p > .05$) between groups in demographical characteristics (Table 1). However, the average body weight for the walking-only group was greater than the Powerbelt™ group. Age and height were similar between groups.

Participation and Attrition Rate

Initially, 35 participants were recruited. Eleven (31.4%) participants, 4 males and 7 females, did not complete the study for various reasons. Six of these participants were in the treatment (Powerbelt™) group and five in the control (walking-only) group. Four participants did not complete the study because of shin splints, two for hamstring muscle strain, two because of scheduling conflicts, two due to lack of compliance and one due to illness.

The initial measurements of the drop-out group did not differ from the group that completed the study (Table 2). Independent-samples *t*-tests were calculated to compare

Table 1. Demographical characteristics of groups (Mean ± SD)

	Powerbelt™ Group	Walking-only Group
Total Participants	12	12
Males / Females	4 / 8	5 / 7
Age (yr)	38.9 ± 8.4	38.1 ± 11.1
Weight (Kg)	77.9 ± 8.9	84.7 ± 13.5
Height (cm)	166.0 ± 6.0	167.9 ± 8.2

No significant differences ($p > .05$) between groups

Table 2. Comparison of initial values between drop-out and study groups (Mean ± SD).

Variables	Participants who finished the study (N = 24)	Participants who dropped out the study (N = 11)
$\dot{V}O_2$max (ml/kg/min)	29.8 ± 5.7	29.3 ± 6.1
Maximum Heart Rate (bpm)	189 ± 12	187 ± 10
Percent of Relative $\dot{V}O_2$max at lactate threshold (%)	64.3 ± 8.2	66.3 ± 6.1
$\dot{V}O_2$ at lactate threshold (ml/kg/min)	19.7 ± 3.5	18.9 ± 4.0
Relative Body Fat (%)	30.8 ± 6.4	32.0 ± 8.2
Body Mass Index	29.1 ± 2.7	29.7 ± 3.4

maximum oxygen consumption ($\dot{V}O_2$max), maximum heart rate (HRmax), percent of oxygen consumption at the lactate threshold (% $\dot{V}O_2$max at LT), oxygen consumption at the lactate threshold ($\dot{V}O_2$ at LT), percent of body fat (%BF), and body mass index (BMI). No significant differences were found for initial $\dot{V}O_2$max ($t(33) = 0.212$, $p = 0.833$), HRmax ($t(33) = 0.571$, $p = 0.572$), % $\dot{V}O_2$max at LT ($t(28) = -0.681$, $p = 0.502$), $\dot{V}O_2$ at LT ($t(28) = 0.563$, $p = 0.578$), %BF ($t(33) = -0.454$, $p = 0.653$), and BMI ($t(33) = -0.581$, $p = 0.565$) between participants who completed the study and participants who dropped out.

Effects of Powerbelt™ on Aerobic Capacity

It was hypothesized that $\dot{V}O_2$max would improve to a greater extent following eight weeks of a combined Powerbelt™-with-walking training program compared to walking only program. A 2 x 2 repeated measures ANOVA was performed on maximum oxygen consumption ($\dot{V}O_2$max). While training improved $\dot{V}O_2$max ($F(1,22) = 42.360$, $p < 0.001$), there was no interaction effect between training and group ($F(1,22) = 0.013$, $p = 0.909$) and no main effect for group ($F(1,22) = 0.329$, $p = 0.572$), indicating that $\dot{V}O_2$max improved similarly in the groups (Table 3). The Powerbelt™ and walking-only group showed a 9.8 % and 10.7 % increase in $\dot{V}O_2$max, respectively.

Heart rate, ventilation, and RER values measured during maximal exercise are provided in Table 3. Corresponding with an increase in $\dot{V}O_2$max, $\dot{V}_e$ max increased significantly ($F(1,22) = 6.118$, $p = 0.022$), demonstrating that $\dot{V}_e$ max improved equally in both groups. The percent increase in $\dot{V}_e$ max for the Powerbelt™ and walking-only

Table 3. Maximum responses to exercise (before and after training) in the Powerbelt™ and walking-only groups.

Variables	Powerbelt™ Group (n = 12)	Walking-only Group (n = 12)
$\dot{V}O_2max$ (ml/kg/min)		
Pre	30.5 ± 5.8	29.0 ± 5.8
Post*	33.5 ± 7.0	32.1 ± 5.3
Maximum Heart Rate (bpm)		
Pre	192 ± 12	187 ± 12
Post	187 ± 15	187 ± 9
Maximum Ventilation (L/min)		
Pre	94.1 ± 18.4	95.4 ± 23.9
Post*	100.2 ± 28.5	100.9 ± 20.9
Maximum Respiratory Exchange Ratio		
Pre	1.19 ± 0.05	1.17 ± 0.08
Post	1.18 ± 0.06	1.17 ± 0.06

* Significantly different ($p < 0.05$) from pretest.

group was 6.48 % and 5.77 %, respectively. Maximum HR and RER did not change with training ($F(1,22) = 3.094$, $p = 0.092$) and ($F(1,22) = 0.413$, $p = 0.527$), respectively.

Effects of Powerbelt™ on Body Mass

It was hypothesized that body mass (BM) would decrease significantly ($p < 0.05$) after the combined Powerbelt™-walking training program when compared to the walking-only program. A 2 x 2 repeated measures ANOVA was performed on BM. A non significant training effect on BM was shown ($F(1,22) = 4.112$, $p = 0.055$), although there was a trend for a reduction. A reduction in BM was evident, however, in that BMI decreased with training (Table 4).

Effects of Powerbelt™ on Body Mass Index

It was expected that body mass index (BMI) would decrease significantly ($p < 0.05$) following the Powerbelt™-with-walking training program compared to a walking only program.

A 2 x 2 repeated measures ANOVA was performed on BMI. Despite there being no significant decrease in BM, BMI decreased with training ($F(1,22) = 5.198$, $p = 0.033$) (Table 4). There was no interaction effect between training and group ($F(1,22) = 0.080$, $p = 0.780$) and no main effect for group ($F(1,22) = 2.614$, $p = 0.120$), demonstrating that BMI decreased similarly in the groups (Table 4).

Effects of Powerbelt™ on Percent Body Fat

It was also hypothesized that percent body fat (%BF) would decrease significantly ($p < 0.05$) following the training program in participants randomly assigned to the Powerbelt™ group compared to those randomly assigned to the walking-only group. A 2 x 2 repeated measures ANOVA was performed on %BF. Percent body fat decreased with training ($F(1,22) = 6.195$, $p = 0.021$), but there was no interaction effect between training and group ($F(1,22) = 1.445$, $p = 0.242$) and no main effect for group ($F(1,22) = 0.0842$, $p = 0.774$), indicating that %BF improved comparably in both groups (Table 4).

A 2 x 2 repeated measures ANOVA was performed on thigh skinfold thickness and sum of skinfold thickness (Table 4). Training resulted in a decrease in thigh skinfold thickness ($F(1,22) = 9.661$, $p = 0.005$). However, there was no interaction effect between training and group ($F(1,22) = 0.885$, $p = 0.357$) and no main effect for group ($F(1,22) = 0.331$, $p = 0.571$), indicating that thigh skinfold thickness decreased similarly in the groups. The thigh skinfold thickness decreased 9.4 % in the Powerbelt™ group while it decreased 5.7 % for the walking-only group. Thigh skinfold thickness was studied because it was the one common skinfold site for men and women. Similarly, the sum of skinfold thickness decreased with training ($F(1,22) = 6.779$, $p = 0.016$). However, there was no interaction effect between training and group ($F(1,22) = 0.968$, $p = 0.336$) and no main effect for group ($F(1,22) = 0.289$, $p = 0.596$), indicating that sum of skinfold thickness decreased similarly in the groups. The Powerbelt™ and walking-only group had a 8.2 % and 3.6 % decrease in the sum of skinfold thickness, respectively.

Table 4. Body composition before and after training in the Powerbelt™ and walking-only groups.

Variables	Powerbelt™ Group (n = 12)	Walking-only Group (n = 12)
Body Mass (Kg)		
Pre	77.9 ± 9.0	84.7 ± 13.6
Post	77.1 ± 9.7	84.2 ± 13.9
BMI		
Pre	28.2 ± 2.1	29.9 ± 2.9
Post*	27.9 ± 2.5	29.7 ± 3.1
%BF (%)		
Pre	30.7 ± 6.2	30.9 ± 6.9
Post*	28.9 ± 6.5	30.2 ± 7.1
Thigh Skinfold (mm)		
Pre	35.4 ± 14.2	31.2 ± 16.6
Post*	32.1 ± 12.5	29.5 ± 14.9
Sum of Skinfolds (mm)		
Pre	88.2 ± 18.3	90.6 ± 25.6
Post*	81.0 ± 16.5	87.3 ± 21.4

* Shows a significant ($p < 0.05$) training effect.

Training Effects on Lactate Threshold

A 2 x 2 repeated measures ANOVA was performed on each of the following variables: percent of maximum oxygen consumption at lactate threshold (% $\dot{V}O_2$max at LT), oxygen consumption at lactate threshold ($\dot{V}O_2$ at LT), heart rate at lactate threshold (HR at LT), minute ventilation at lactate threshold ($\dot{V}_e$ at LT), respiratory exchange ratio at lactate threshold (RER at LT), rating of perceived exertion at lactate threshold (RPE at LT), and blood lactate at lactate threshold (Table 5).

While a significant training effect on the % $\dot{V}O_2$max at LT was evident (F(1,18) = 14.368, p = 0.001) (Table 5), there was no interaction effect between training and group (F(1,18) = 0.563, p = 0.463) and no main effect for group (F(1,18) = 0.0914, p = 0.766), indicating that the % $\dot{V}O_2$max at LT improved similarly in the groups. The Powerbelt™ and walking-only group showed a 9.03 % and 13.9 % increase in the % $\dot{V}O_2$max at LT, respectively.

Although $\dot{V}O_2$ at LT increased after training (F(1,18) = 27.023, p < 0.001), no interaction was present between training and group (F(1,18) = 0.101, p = 0.754) and no main effect for group (F(1,18) = 0.385, p = 0.543), showing that $\dot{V}O_2$ at LT increased comparably in both groups. The Powerbelt™ and walking-only group had a 21.4 % and 26.0 % increase in the $\dot{V}O_2$ at LT, respectively, with respect to the pretest.

HR at LT also increased. The main effect for training was significant (F(1,18) = 4.473, p = 0.049); however, training x group interaction (F(1,18) = 1.409, p = 0.251) and main effect for group (F(1,18) = 0.0601, p = 0.809) were not significant. The HR at LT improved similarly in the groups. The Powerbelt™ had a 2.1% increase in the HR at LT while the walking-only group had a 7.5 % increase.

Table 5. Responses to exercise at lactate threshold (before and after training) in the Powerbelt™ and walking-only groups.

Variables	**Powerbelt™ Group (n = 11)**	**Walking-only Group (n = 9)**
Relative $\dot{V}O_2max$ (%)		
Pre	65.3 ± 8.7	63.0 ± 8.0
Post*	71.2 ± 7.4	71.8 ± 6.7
$\dot{V}O_2$ (ml/kg/min)		
Pre	20.3 ± 2.9	18.9 ± 4.3
Post*	24.6 ± 5.2	23.8 ± 5.4
Heart Rate (bpm)		
Pre	149 ± 17	147 ± 16
Post*	152 ± 11	158 ± 12
Ventilation (L/min)		
Pre	44.8 ± 6.3	45.1 ± 11.1
Post*	53.6 ± 11.8	56.1 ± 11.2
Respiratory Exchange Ratio		
Pre	0.96 ± 0.04	0.93 ± 0.07
Post	0.95 ± 0.04	0.93 ± 0.05
Blood Lactate (Mmol)		
Pre	3.0 ± 0.5	2.9 ± 0.8
Post	3.2 ± 0.8	3.1 ± 0.7
Rating of Perceived Exertion		
Pre	13.3 ± 2.7	12.8 ± 1.8
Post*	11.4 ± 2.0	11.1 ± 1.6

* Significantly different ($p < 0.05$) from pretest.

Associated with an increase in $\dot{V}O_2$, $\dot{V}_e$ at LT also increased (F(1,18) = 19.511, p < 0.001), but there was no interaction effect between training and group (F(1,18) = 0.224, p = 0.642) and no main effect for group (F(1,18) = 0.111, p = 0.743), indicating that $\dot{V}_e$ at LT improved comparably in the groups. The Powerbelt™ and the walking-only group showed a 19.8% and 24.4 % increase in $\dot{V}_e$ at LT, respectively.

There was no change in RER at LT after training was (F(1,18) = 0.259, p = 0.617)**.** Even though RPE at LT was lower after training (F(1,18) = 6.380, p = 0.021), there was no interaction effect between training and group (F(1,18) = 0.0199, p = 0.889) and no main effect for group (F(1,18) = 0.389, p = 0.541), indicating that RPE at LT improved similarly in the groups. The Powerbelt™ and the walking-only group had a 14.02 % and 13.07 % decrease in RPE at LT, respectively. Blood lactate at LT did not change after training (F(1,18) = 2.082, p = 0.166).

Heart Rate and RPE during Training

A 2x2 repeated measures ANOVA was used to determine group and training week differences (Powerbelt™ and walking-only) in HR and RPE responses during training sessions for week 1 and week 8 (Table 6). Values were averaged across sessions for weeks 1 and 8. No significant main effects or interactions were found. Regarding HR, the time of training x group interaction (F(1,22) = 0.293, p = 0.594), the main effect for time of training (F(1,22) = 3.031, p = 0.096), and the main effect for group (F(1,22) = 1.622, p = 0.216) were all not significant. For RPE, the time of training x group interaction (F(1,22) = 0.955, p = 0.339), the main effect for time of training (F(1,22) = 1.041, p = 0.319), and the main effect for group (F(1,22) = 0.000718, p = 0.979) were all

Table 6. Average heart rate (HR) and rating of perceived exertion (RPE) responses during training sessions of week 1 and 8.

Variables	Powerbelt™ Group	Walking-Only Group
Heart Rate (bpm)	(n = 12)	(n = 12)
Week 1	148 ± 9	142 ± 13
Week 8	150 ± 7	145 ± 12
Rating of Perceived Exertion	(n = 11)	(n = 11)
Week 1	12.5 ± 1.2	12.9 ± 1.4
Week 8	12.5 ± 1.6	12.2 ± 0.9

No significant differences ($p > 0.05$)

not significant. The training HR and RPE were not affected by either time of training or group.

Absolute and Relative Times Using the Powerbelt™

A one-way repeated measures ANOVA was calculated comparing the absolute time using the Powerbelt™ during the training sessions at three different times: week 1, week 5, and week 8. A significant effect was found ($F(2,22) = 119.565$, $p < 0.001$). A follow-up Holm-Sidak method revealed that absolute time (minutes) using the Powerbelt™ increased significantly from week 1 (15.3 ± 2.3 min) to week 5 (33.3 ± 4.5 min) and from week 1 to week 8 (33.1 ± 4.3 min). No difference between weeks 5 and 8 was observed. Participants increased their walk time from30 to 40 minutes on the 5th session and from 40 to 50 minutes on the 10th session of the training program (30 sessions in total).

A one-way repeated measures ANOVA was also performed comparing the relative time using the Powerbelt™ at three different times: week 1, week 5, and week 8. A significant effect was found ($F(2,22) = 16.458$, $p < 0.001$). A follow-up Holm-Sidak method showed that relative time using the Powerbelt™ increased significantly from week 1 (51.0 ± 7.8 %) to week 5 (66.6 ± 9.0 %) and from week 1 to week 8 (66.27 ± 8.7 %). No difference between weeks 5 and 8 was observed. Participants increased the relative time using the Powerbelt™ as their training progressed, regardless of an increase in the Powerbelt™ resistance.

Reliability of Skinfold Thickness Measures

To test the reliability of skinfold thickness measures, an independent-sample *t*-test was performed on 11 participants comparing the mean sum of skinfold measurements from two separate occasions (within 1-7 days). No significant difference was found ($t(20) = 0.305$, $p > 0.763$). The mean sum of the skinfolds measured on the first occasion was 76.7 ±12.2 mm while the sum of the skinfolds measured on the second time was 75.1 ±12.5 mm. In addition, a Pearson correlation revealed a strong positive correlation ($r(9) = 0.933$, $p < 0.0001$) between the two sums of skinfolds, indicating a significant linear relationship between them.

CHAPTER FIVE

DISCUSSION

The purpose of this study was to determine whether adding arm exercise while walking during an 8-week walking regimen would result in greater increases in $\dot{V}O_2$max and a greater reduction in BMI, BM, and %BF of overweight adults when compared to walking without arm exercise.

Effects of Powerbelt™ on aerobic capacity

It was hypothesized that $\dot{V}O_2$max measured during leg exercise would improve to a greater extent following eight weeks of a combined Powerbelt™-with-walking program compared to a walking-only program. The results of the present study showed that improvements in $\dot{V}O_2$max were similar between arm and leg exercise and leg-only exercise. This indicates that in regard to aerobic capacity, the addition of arm exercise to walking did not provide additional benefits compared to walking only for the current sample of overweight adults.

A higher increase in $\dot{V}O_2$max was expected in the Powerbelt™ group compared to the walking-only group based on the previous observations that $\dot{V}O_2$ was significantly greater when adding an upper-body workout to walking (2, 6, 12, 13, 18, 31, 36, 41, 45, 48, 56, 59, 60) and that there was a transfer effect from training (30, 54). Using various forms of upper body exercise (e.g., walking poles, handheld weights) $\dot{V}O_2$ was approximately 7 to 52% higher compared to walking only. The magnitude of increase was dependent upon several things: walking speed, arm movement, and resistance applied. Similarly, we observed a 32% increase in $\dot{V}O_2$ during pilot testing while walking and using the Powerbelt™ compared to walking-only.

The use of various size handheld weights has resulted in a range of increases in $\dot{V}O_2$. Zarandona et al. (59) demonstrated a 17% increase in $\dot{V}O_2$ when walking with a 5-lb hand weight in each hand compared to walking with 1-lb hand weights or no weights. Similarly, Graves et al. (13) found a 12% increase in $\dot{V}O_2$ while using 3-lb hand weights and Miller and Stamford (36) showed that at 4 mph $\dot{V}O_2$ increased 26% during walking with 5-lb hand weights compared to walking with no weights. Auble et al. (2) showed that when using 3-lb hand weights with an arm elevation of 1.07 m, $\dot{V}O_2$ increased 40.5% when compared to walking with no weights at 3.5 mph. This indicated that arm swing affects $\dot{V}O_2$ significantly. Makalous et al. (31) demonstrated that $\dot{V}O_2$ while walking with 1-lb hand weights was 7% greater than normal walking. Wearing wrist weights also resulted in $\dot{V}O_2$ increases. Graves et al. (12) found that $\dot{V}O_2$ was 15.4% greater during walking with 3-lb wrist weights than during walking with no weights. Taking into account the average of the percent increases in $\dot{V}O_2$ and the amount of weight utilized in the previous studies, $\dot{V}O_2$ increased 19.6% when using 3-lb hand weights compared to walking with no weights.

Studies investigating the effects of adding walking poles to walking have found similar results. Rodgers et al. (48) showed a 12% increase in $\dot{V}O_2$ when walking poles were added compared to walking only. Walter et al. (56) found that the energy cost of walking increased by 21% when walking poles were added to walking. Similar to the effects of walking poles, the dual-action treadmill applies resistance to arm movement. Butts et al. (6) determined that the metabolic cost of participants increased 55% when arm movement was incorporated to walking.

Increases in $\dot{V}O_2$ when adding an aerobelt or Powerbelt™ to walking have also been observed. Nurge et al. (41) indicated that the difference in $\dot{V}O_2$ between aerobelt walking and normal walking was 52%. In addition, Hopkins et al. (18) found that when participants simulated a cross-country skiing action using the aerobelt, $\dot{V}O_2$ increased 52% in comparison to normal walking. Zedaker et al. (60) showed that $\dot{V}O_2$ increased 64% when using a Powerbelt™ with resistance 3 compared to walking only. Our pilot data showed a 32% increase in $\dot{V}O_2$ while using a Powerbelt™ with resistance 2 compared to walking only.

Cross-Training Effects of Powerbelt™

A transfer effect of training, commonly called cross training, has been observed from training effects passed from trained to untrained musculature. The results of the present study do not support the findings of Loftin et al. (30). They found a transfer effect of training when the arm-trained group was tested during peak leg exercise. The investigators randomly assigned participants to an experimental group which performed arm training and to a control group which did not exercise. The results showed that $\dot{V}O_2$ increased 7% in the arm-trained group after leg testing. However, the control group of this study was not involved in any exercise training. Therefore, differences in $\dot{V}O_2$peak between the exercising and control group could be expected from the fact that exercise training by itself, regardless of muscle mass involvement, causes physiological and metabolic adaptations. In contrast, the control group of the present study (walking-only group) was involved in exercise training. Had a difference in $\dot{V}O_2$max been seen between the Powerbelt™ and walking-only group, it would have been solely attributed to a transfer effect of training.

In addition, Tordi et al. (54) found a transfer effect of training in the upper body following a lower-body endurance training program in terms of peak work output. In contrast to Loftin et al. (30), this research study had two experimental groups which were involved in different exercise training protocols. The leg-trained group significantly ($p < 0.05$) improved peak work output (+11%) in arm ergometry. However, differences in $\dot{V}O_2$peak between groups were not observed. Interestingly, and supported from the findings of the present study, differences in $\dot{V}O_2$peak were observed within groups during pre and post testing, indicating that exercise training significantly increased the aerobic capacity of individuals despite of group type.

On the other hand, the results of the present study, in terms of the transfer effects of training on aerobic capacity, support the findings of Bhambhani et al. (3). They found no transfer effects of training from one muscle group to the other in terms of $\dot{V}O_2$peak. Arm cycle training had no significant influence on the peak physiological responses observed during leg cycling, and leg cycle training had no significant influence on the peak physiological responses during arm cycling. However, another reason why we found no difference in $\dot{V}O_2$max between groups may be because $\dot{V}O_2$max was measured without the Powerbelt™. Nevertheless, some evidence for transfer effects of training may be inferred from the present study since the use of the Powerbelt™ during training sessions caused a similar increase in $\dot{V}O_2$max compared to that of walking only. That is, the use of the upper body by the Powerbelt™ group during the training sessions may have contributed to some degree in the attainment of a similar $\dot{V}O_2$max observed when only the lower body was trained.

In line with the results of Mostardi et al. (38), we conclude that regardless of the amount of muscle mass recruited in the training program, the levels of acquired conditioning were equal. No training effects occurred during maximal leg testing after conditioning the arms and legs because the workloads were similar for both conditions. Even though the relative workload in the present study was not the same between the two groups, with the Powerbelt™ group exercising at a relatively higher workload, no transfer effects of training were observed. Therefore, had the arm and leg group in the study by Mostardi et al. (38) exercised at a relatively higher workload, changes in $\dot{V}O_2$ compared to the leg group may have been nonsignificant. Similar to the results of the present study and those by Tordi et al. (54), Mostardi et al. (38) found that $\dot{V}O_2$peak improved for both leg + arm and leg-only groups after the training program.

It is important to remark that the previous researchers conducted their exercise training programs on a cycle ergometer and we used a treadmill. To our knowledge, no studies investigating the transfer effects of training have utilized an aerobic weight-bearing exercise such as treadmill walking. Similarly, no studies have used the Powerbelt™ to determine whether exercise training in the upper-body conveys a transfer effect of training to the lower body. The use of the Powerbelt™ in research studies investigating the transfer effects of training ™, in contrast to the use of arm ergometers, allows researchers to better mimic popular exercise modalities, thus, improving the applicability of the results obtained in a control setting.

The only training study that utilized upper-body equipment (walking poles), equivalent to that used contemporarily, to determine the effects of training on muscular endurance was conducted by Karawan et al. (22). Participants were randomly assigned to one of three groups: walking with poles, walking without poles, and controls. This was a very good design to determine the transfer effects of training from the upper to the lower body. However, the scope of the study by Karawan et al. (22) was to determine changes in muscular endurance; aerobic capacity changes after the training program were not considered.

Effects of Powerbelt™ on Body Composition

It was hypothesized that %BF would decrease significantly ($p < 0.05$) following the training program in participants randomly assigned to the Powerbelt™ group compared to those randomly assigned to the walking-only group. Furthermore, it was expected that BMI would decrease significantly ($p < 0.05$) following the Powerbelt™-with-walking training program compared to a walking only program. Finally, it was also hypothesized that BM would decrease significantly ($p < 0.05$) after the combined Powerbelt™-walking training program when compared to the walking-only program.

Even though the results showed that adding an upper-body workout to walking did not cause a significant reduction in %BF compared to walking only, both groups reduced %BF significantly. These results are not consistent with what Leon et al. (29) found in terms of the magnitude of %BF reduction. They showed that %BF decreased 25.3% after the completion of a 16-week vigorous walking program compared to a 6% and 2.3% decrease in this study for the Powerbelt™ and walking-only group, respectively. However, the exercise intensity and duration were considerably higher during Leon's study compared to that employed in the present study; furthermore, the length of training in the earlier study was twice as long. In addition, Leon et al. (29) had participants walk on a treadmill at speeds up to 3.2 mph at a 10% grade for 90 min five days per week.

Even though the exercise intensity of the present study was moderately high (at or slightly under the LT), it cannot be compared to that of walking at a 10% grade for 90 min. The duration for each of our training sessions was progressively increased from 30 min to 50 min. Similarly, the frequency of exercise sessions per week was increased progressively from three times per week to five times per week. In addition, exercise training in the present study was conducted over eight weeks. The intensity, duration, and frequency were progressively increased in the present study with the purpose of reducing the likelihood of developing acute injuries such as shin splints. This conservative approach was initially undertaken to minimize the dropout rate and encourage exercise adherence among participants.

In another training study, which consisted of brisk walking or light jogging on a treadmill, a 12% decrease in BF was observed (50). The percent decrease in BF was twice as much as that observed in the present study. However, several distinguishing characteristics in the methodological design and participants´ anthropometric data may have caused the greater reduction in %BF observed in this study. First, the duration of the training program was four weeks longer than the one conducted in the present study. Second, participants were required to exercise during each session until they expended 700 kcal. That is, the investigators controlled energy expenditure during each exercise session. In contrast, in the present study training HR was the variable controlled to assure that participants exercised at or slightly below LT. In the present study, participants in the Powerbelt™ group expended 502 kcal per session only during the last two weeks of training. Therefore, 200 more kcals were expended per exercise session in the study by Ross et al. (50) compared to the last 2 weeks of training in the present study. The difference in energy expenditure per session between participants in the present study and those in the study by Ross et al. (50) could have easily exceeded 300 kcal since a lower duration, frequency, and upper-body intensity was present in the beginning of the present study compared to the last two weeks.

In addition, the average BMI of those in the study by Ross et al. (50) was three points higher (32 kg/m^2) than that observed in participants in the present study (29 kg/m^2). According to the classification of individuals in terms of BMI (1), participants in the study by Ross et al. (50) were on average obese while participants in the present study were, on average, overweight. This could have been one reason why participants in the study by Ross et al. (50) had a greater reduction in %BF based on the fact obese individuals have a greater room for improvement than overweight subjects. Any exercise program may cause greater training effects for individuals considered obese than individuals considered overweight. Finally, caloric intake was closely monitored in the study by Ross et al. (50) which could have been one more reason why their participants showed a greater reduction in %BF compared to participants in the present study. In conclusion, the reduction in %BF, though statistically significant, was considerably lower than in previous studies that employed greater volumes of exercise and longer training periods (29, 50).

The dietary intake of participants in this study was not controlled which could have confounded the results. Participants were asked on a weekly basis to recall their daily dietary intake and were constantly encouraged to maintain their initial energy intake. However, the motivation of losing weight and the concurrent engagement in exercise training could have induced participants to change their nutritional habits. For instance, one participant reported during the training program that she no longer desired fast food or adding salt to meals. This change in nutritional behavior may have been the trend for participants which could have potentially reduced the gap in terms of energy balance between the walking-only and Powerbelt™ group, thus, minimizing the effects of training in regards to caloric expenditure. It is known that exercise causes positive physiological and psychological changes in the body, but future research should study the extent to which exercise could cause individuals to change their food choices.

BM was not significantly different between groups after the training program even though both groups showed a slight reduction in BM. Several studies have concluded that the minimum public health recommendations of 150 min/week of physical activity and 1000 kcal/week of energy expenditure are not sufficient to cause a significant reduction in BM (19, 20, 23, 25). During the final two weeks of training, we estimated that our participants were expending about 2500 kcal/week during exercise. The findings of the present study support what Jakicic et al. (20) found. They determined that the minimum recommended training duration of 150 minutes per week (39) is not sufficient to elicit a significant reduction in BM. They observed that the greatest magnitude of weight loss occurred when participants engaged in exercise activity for more than 280 min per week, which is equivalent to ≥ 2500 kcal/week. In the present study, participants exercised for 250 min per week only during the last two weeks of the training program. During the first and sixth week of training, the exercise time per week was progressively increased from 90 min to 200 min. The caloric expenditure during exercise for participants in the present study during the last two weeks of training was greater (Powerbelt™ = 2510 kcal; Walking-only = 2135 kcal) than the minimum public health recommended value of expending 1000 kcal/week (39). However, the caloric expenditure for the entire training program could have been closer to 1000 kcal/week since the exercise frequency and duration were not the same to that of the last two weeks. Exercise frequency and duration was progressively increased. In view of the results of Jakicic et al. (20), had the participants in the present study continued beyond 8 weeks, a significant decrease in BM may have been observed.

In addition, the findings of the present investigation support two studies. Jakicic and Gallagher (19) revealed that 60 minutes, as opposed to only 30 minutes, of daily activity at moderate intensity was associated with the greatest magnitude of weight loss. These findings by Jakicic and Gallagher (19) are consistent with those of Kraus et al. (25) who found that increasing exercise duration is more effective than increasing exercise intensity when weight reduction is the goal. Taking into account the study of Klem et al. (23), who found that participants who lost weight and maintained the loss for 5 years were expending on average 2827 kcal/week through physical activity, the loss in BM achieved by participants during this study may not be maintained for 5 years.

Walking on a treadmill for more than 50 min per day, over an 8-week period, may be too strenuous for a sedentary population. Even though it seems that exercise duration and frequency must be increased above the recommended level of physical activity (150 min/week) when significant weight loss is the goal, such a training program could increase the dropout rate as well as increase the likelihood of acute injuries. For instance, four participants dropped out of the present study because they reported shin splints during the first three weeks of the study. The training sessions during the first three weeks of the study were 30-40 min long and were conducted on average three times per week. It suggests that even short exercise sessions on alternating days may impose a relatively high risk of injury to sedentary individuals. Therefore, the means to have the greatest reduction in weight loss through an increase in exercise duration, frequency, and intensity may be sacrificed during the initiation of an exercise program in order to maximize exercise adherence.

It is important to remark that 12 participants (50%) reported feeling shin splints at some point during the study. However, these participants were successful in continuing the training program. It would be interesting to know whether a higher pain tolerance or greater cognitive coping mechanisms is associated with keeping individuals from dropping out.

Since BMI is directly dependent on BM, the slight reduction in BM observed in both groups resulted in a small reduction in BMI. In other words, the results of the present study revealed that BMI was not significantly different between groups after the training program. However, both groups showed a decrease in BMI after the training program, demonstrating the benefits of 8 weeks of aerobic exercise for weight loss.

Effects of Powerbelt™ on Energy Expenditure

We believed that the significantly higher energy expenditure during Powerbelt™ walking, based on past studies and on our pilot data, would provide a more profound stimulus for aerobic capacity improvements. However, during the training sessions, Powerbelt™ exercise could not be sustained for the entire training session. Local muscular fatigue in the upper body was the major factor for participants ceasing the use of the Powerbelt™. On average, participants engaged in the Powerbelt™ exercise 61% of the time during training.

Although participants´ caloric expenditure during the training sessions was not measured, it could be estimated from their average exercise HR and HR reserve (HRR). Exercise HR was averaged over the last two exercise sessions. The HRR was computed from the HRmax obtained during the posttest. From the percentage of HRR at which participants exercised during the last two sessions % $\dot{V}O_2$ R was determined. Similarly, $\dot{V}O_2$ R was calculated from posttest $\dot{V}O_2max$ values. Once the absolute $\dot{V}O_2$ value corresponding to the last two exercise sessions was determined, the caloric expenditure was calculated from the assumption that 1 liter of oxygen is equivalent to 5 kcal. From these calculations, the average energy expenditure during the last two 50-min exercise sessions was estimated to be 427 kcal for the walking-only group.

For the Powerbelt™ group, the average time using the Powerbelt™ was determined to be 33 min. Using the pilot data to estimate energy expenditure during use of Powerbelt™, the average energy expenditure for the Powerbelt™ group during the last two 50-min exercise sessions was estimated to be 502 kcal. The difference between groups in terms of energy expenditure during the last two exercise sessions was 75 kcal.

However, the 32% increase in energy expenditure during pilot testing occurred when participants used resistance 2 on the Powerbelt™. The participants in the present study were using either resistance 3 or 4 during the last two weeks of training. Therefore, the difference in energy expenditure between groups during the last two exercise sessions could have been higher. For instance, Zedaker et al. (60) showed a 64% increase in $\dot{V}O_2$ in participants walking with a Powerbelt™ using resistance 3 compared to walking only. Taking into account the increase in energy expenditure observed during the pilot test (32%) conducted before the present study and the investigation by Zedaker et al. (60) (64%), energy expenditure appears to increase twofold when using resistance 3 compared to using resistance 2 of the Powerbelt™. This could feasibly have increased energy expenditure by an additional 75 kcal each session. The results of these calculations suggest that energy expenditure in the Powerbelt™ group was greater than in the walking-only group.

Benefits of Walking with and without Powerbelt™ on Lactate Threshold

Even though a significant difference in %BF, BM, and BMI was not observed between the Powerbelt™ and walking-only group, cardiovascular and metabolic adaptations occurred in both groups as consequence of the training program. LT was measured during pretests to determine initial individual exercise intensities. The % $\dot{V}O_2$max at LT improved similarly in both groups after training. It is a major indication that participants, regardless of the group they were involved in, relied less on anaerobic energy processes during submaximal exercise after the training program.

In line with the previous result, both groups showed an improvement in absolute $\dot{V}O_2$ at LT. That is, participants in both groups consumed more oxygen at the stage where lactate had started to accumulate in the blood.

Another cardiorespiratory adaptation that occurred for both groups after the training program was an increase in both $\dot{V}_e$ and HR at LT which is in line with the increase in $\dot{V}O_2$. Interestingly, RPE at LT was significantly lower for both groups during posttest. Participants perceived less effort when they attained their LT. This was likely due to participants´improved tolerance to exercise and familiarization to wearing the headset and/or having their lactate measured, which could have resulted in less test anxiety.

Training Intensity

The lack of significant differences in the training load may have been the main reason why no differences in $\dot{V}O_2$max were observed between groups. The average training HR from the first and eighth week of training did not differ significantly between the Powerbelt™ and walking-only group; although the HR for the Powerbelt™ group tended to be higher (by about 5 bpm) during week one and eight compared to the walking-only group. Participants in the Powerbelt™ group may have achieved a higher HR if they had used the Powerbelt™ for the entire training session.

Absolute training intensity (workload), which was based on initial individual LT, was progressively increased for both the Powerbelt™ and walking-only groups according to HR response, corresponding to the pretest LT and was kept constant throughout training. When the Powerbelt was used during training, HR increased by approximately

10%. For example, one participant in the Powerbelt™ group showed a 9% increase in training HR during the first week when exercising the arms compared to walking only. The same participant during week eight showed a 10% increase in HR when exercising the arms compared to walking only.

RPE during the training sessions did not differ significantly between groups, nor did it differ from week one to week eight. The lack of significant changes in RPE during the training program may have been the result of the participants' increasing tolerance to exercise since absolute training intensity was higher from week one to eight. Although average RPE during a training session between groups was not significantly different during weeks one and eight, participants in the Powerbelt™ group reported higher RPEs while exercising the arms. For example, one participant in the Powerbelt™ group reported a 9% higher RPE when exercising the arms compared to walking only during week one and 11% higher during week 8.

These results demonstrate that participants in the Powerbelt™ group exercised at a greater intensity (higher HR and RPE during use of the Powerbelt™). However, this training intensity or the length of time using the Powerbelt™ (61% of total duration) was not enough to elicit significant differences in $\dot{V}O_2$max, %BF, BMI, and BM between groups. Perhaps if Powerbelt™ exercise had been performed for longer periods of time, a greater training response may have occurred.

Psychological Benefits of Walking with and without Powerbelt™

Some participants reported psychological benefits during the training program. For example, one participant stated that she could concentrate better at her work and that exercise made her stress level go down. Participant's internal motivation was also observed throughout the study. Many participants reported that their weight had stayed the same, but they could fit better in their clothes, particularly at their waist line. This supports the work by Parkkari et al. (42) who determined that regular walking during a golf game reduced waist circumference.

Conclusion

In summary, the addition of an upper-body workout to walking did not result in additional increases in $\dot{V}O_2$max. In addition, a greater reduction in %BF, BM, and BMI was not observed when adding an upper-body workout to walking.

Future research interested in investigating the effects of adding an upper-body workout to walking on changes in body fat should consider accurately recording the energy intake of participants since energy balance directly influences changes in body fat. Increasing the duration of the training program beyond eight weeks to determine if eight weeks was not simply long enough for discernable benefits to be evident is also of interest.

In addition, future research should be conducted to examine whether or not adding an upper-body workout to walking increases coordination and balance, and upper-body muscular endurance and strength. At the beginning of the training program, participants showed poor balance and coordination when using the Powerbelt™. However, as the training program progressed with an increase in intensity and duration, the lack of balance and coordination was not evident.

Adding an upper-body workout to walking may improve the balance and coordination in activities of daily living such as walking and carrying shopping bags or suitcases. Furthermore, upper-body muscular endurance and strength, which are fundamental in activities of daily living such as pushing a door, may improve after adding an upper-body workout to walking. For instance, participants in the Powerbelt™ group concentrically worked their pectoralis, triceps, and anterior deltoids muscles when performing the cross-country skiing action.

Finally, it would be interesting to know whether or not the implementation of a long-term (6 months) Powerbelt™-walking program in corporate and clinical settings, focused on weight loss, results in both improved adoption and adherence rate and greater caloric expenditure compared to walking only. Using the Powerbelt™ in some exercise sessions may reduce the likelihood of individuals reaching staleness or boredom during an exercise program thereby facilitating the adherence and consequently increasing energy expenditure.

References

1. *ACSM´s Guidelines for Exercise Testing and Prescription*. 6th ed. American College of Sports Medicine. Baltimore, MD: Lippincott Williams & Wilkins; 2000.

2. Auble TE, Schwartz L, Robertson RJ. Aerobic requirements for moving handweights through various ranges of motion while walking. *Phys. Sports Med.* 1987;15(6):133-140.

3. Bhambhani YN, Eriksson P, Gomes PS. Transfer effects of endurance training with the arms and legs. *Med. Sci. Sports Exerc*. 1991;23(9):1035-1041.

4. Borg GA. Psychophysical bases of perceived exertion. *Med. Sci. Sports Exerc*. 1982;14(5):377-381.

5. Bryant DS, Goss FL, Robertson RJ, Metz KF, Feingold DS. Physiological responses to maximal treadmill and handweighted exercise. *Res. Q. Exerc. Sci*. 1993;64(3):300-304.

6. Butts NK, Knox KM, Foley TS. Energy costs of walking on a dual-action treadmill in men and women. *Med. Sci. Sports Exerc.* 1995;27(1):121-125.

7. Colberg SR, Swain DP. Exercise and diabetes control. *Phys. Sports. Med.* 2000;28(4):63-64;69-72;77-78;81.

8. Coleman KJ, Raynor HR, Mueller DM, Cerny FJ, Dorn JM, Epstein LH. Providing sedentary adults with choices for meeting their walking goals. *Prev. Med.* 1999;28:510-519.

9. Duncan GE, Howley ET, Johnson BN. Applicability of VO2max criteria: discontinuous versus continuous protocols. *Med. Sci. Sports Exerc*. 1997;29(2):273-278.

10. Egwu MO. The musculoskeletal effect of intense physical training of non-athletic youth corps conscripts. *Br. J. Sports Med*. 1996;30(2):112-115.

11. Frontera WR, Hughes VA, Krivickas LS, Kim SK, Foldvari M, Roubenoff R. Strength training in older women: Early and late changes in whole muscle and single cells [abstract]. *Muscle Nerve.* 2003;28(5):601-8.

12. Graves JE, Martin AD, Miltenberger LA, Pollock ML. Physiological responses to walking with hand weights, wrist weights, and ankle weights. *Med. Sci. Sports Exerc*. 1988;20(3):265-271.

13. Graves JE, Pollock ML, Montain SJ, Jackson AS, O´Keefe JM. The effect of hand-held weights on the physiological responses to walking exercise. *Med. Sci. Sports Exerc.* 1987;19(3):260-265.

14. Gutin B, Ang KE, Torrey K. Cardiorespiratory and subjective responses to incremental and constant load ergometry with arms and legs. *Arch. Phys. Med. Rehabil*. 1988;69(7):510-513.

15. Hagan RD. Benefits of aerobic conditioning and diet for overweight adults. *Sports Med*. 1988;5(3):144-155.

16. Helmrich SP, Ragland DR, Leung RW, Paffenbarger RS Jr. Physical activity and reduced occurrence of non-insulin-dependent diabetes mellitus. *N. Engl. J. Med*. 1991;325(3):147-152.

17. Heyward VH, Stolarczyk LM. *Applied Body Composition Assessment*. Champaign, IL: Human Kinetics; 1996.

18. Hopkins DR, Hoeger WWK, Van Zee DE, Nurge WJ. Physiologic responses to aero-belt walking. *Med. Sci. Sports Exerc*. 1994;26(Suppl. 5):S43.

19. Jakicic JM, Gallagher KL. Exercise considerations for the sedentary, overweight adult. *Exerc. Sport Sci. Rev*. 2003;31(2):91-95.

20. Jakicic JM, Winters C, Lang W, Wing RR. Effects of intermittent exercise and use of home exercise equipment on adherence, weight loss, and fitness in overweight women. *JAMA*. 1999;282(16):1554-1560.

21. Jensen-Urstad M, Ahlborg G, Sahlin K. High lactate and NH3 release during arm vs. leg exercise is not due to β-adrenoreceptor stimulation. *J. Appl. Physiol*. 1993;74(6):2860-2867.

22. Karawan A, Porcari JP, Butts NK, Postmus AH, Stoughton L, Larkin J. Effects of 12 weeks of walking or exerstriding on upper body strength and endurance. *Med. Sci. Sports Exer*. 1992;24(Suppl.):S138.

23. Klem ML, Wing RR, McGuire MT, Seagle HM, Hill JO. A descriptive study of individuals successful at long-term maintenance of substantial weight loss. *Am. J. Clin. Nutr*. 1997;66(2):239-246.

24. Krall EA, Dawson-Hughes B. Walking is related to bone density and rates of bone loss. *Am. J. Med*. 1994;96(1):20-26.

25. Kraus WE, Houmard JA, Duscha BD, Knetzger KJ, Wharton MB, McCartney JS, Bales CW, Henes S, Samsa GP, Otvos JD, Kulkarni KR, Slentz CA. Effects of the amount and intensity of exercise on plasma lipoproteins. *N. Engl. J. Med*. 2002;347(19):1483-1492.

26. Landers KA, Hunter GR, Wetzstein CJ, Bamman MM, Weinsier RL. The interrelationship among muscle mass, strength, and the ability to perform physical tasks of daily living in younger and older women. *J Gerontl. A. Biol. Sci. Med. Sci*. 2001;56(10):B443-B448.

27. Lee IM, Paffenbarger RS. Preventing coronary heart disease. *Phys. Sports. Med.* 2001;29(2):37-40;43-46;49;52.

28. Lennon D, Nagle F, Stratman F, Shrago E, Dennis S. Diet and exercise training effects on resting metabolic rate. *Int. J. Obes*. 1985;9(1):39-47.

29. Leon AS, Conrad J, Hunninghake DB, Serfass R. Effects of a vigorous walking program on body composition, and carbohydrate and lipid metabolism of obese young men. *Am. J. Clin. Nutr*. 1979;32(9):1776-1787.

30. Loftin M, Boileau RA, Massey BH, Lohman TG. Effect of arm training on central and peripheral circulatory function. *Med. Sci. Sports Exerc*. 1988;20(2):136-141.

31. Makalous SL, Araujo J, Thomas TR. Energy expenditure during walking with handweights. *Phys. Sports. Med*. 1988;16(4):139-148.

32. Marcell TJ. Sarcopenia: causes, consequences, and preventions. *J. Gerontol. A. Biol. Sci. Med. Sci.* 2003;58(10):M911-6.

33. McArdle WD, Katch FI, Katch VL. *Exercise Physiology: Energy, Nutrition, and Human Performance*. 5th ed. Baltimore, MD: Lippincott Williams & Wilkins; 2001.

34. Miles DS, Cox MH, Bomze JP. Cardiovascular responses to upper body exercise in normals and cardiac patients. *Med. Sci. Sports Exerc.* 1989;21(suppl 5):S126-S131.

35. Miles DS, Critz JB, Knowlton RG. Cardiovascular, metabolic, and ventilatory responses of women to equivalent cycle ergometer and treadmill exercise. *Med. Sci. Sports Exerc*. 1980;12(1):14-19.

36. Miller JF, Stamford BA. Intensity and energy cost of weighted walking vs. running for men and women. *J. Appl. Physiol.* 1987;62(4):1497-1501.

37. Morris JN, Hardman AE. Walking to health. *Sports Med*. 1997;23(5):306-332.

38. Mostardi RA, Gandee RN, Norris WA. Exercise training using arms and legs versus legs alone. *Arch. Phys. Med. Rehabil*. 1981;62(7):332-335.

39. National Center for Chronic Disease Prevention and Health Promotion. Surgeon General's Report on Physical Activity and Health. Executive Summary. Available at: www.cdc.gov/nccdphp/sgr/summ.htm. Accessed October 4, 2003.

40. Nieman DC. *Exercise Testing and Prescription: a Health Related Approach*. 5th ed. New York, NY: McGraw-Hill; 2003.

41. Nurge WJ, Van Zee DE, Hoeger WWK. Physiologic responses to aero-belt walking and jogging. *Med. Sci. Sports Exerc*. 1994;26(Suppl. 5):S43.

42. Parkkari J, Natri A, Kannus P, Manttari A, Laukkanen R, Haapasalo H, Nenonen A, Pasanen M, Oja P, Vuori I. A controlled trial of the health benefits of regular walking on a golf course. *Am. J. Med*. 2000;109(2):102-108.

43. Pimental NA, Sawka MN, Billings DS, Trad LA. Physiological responses to prolonged upper-body exercise. *Med. Sci. Sports Exerc*. 1984;16(4):360-365.

44. Porcari JP. Pump up your walk. *ACSM´s Health and Fitness J.* 1999;3(1):25-29.

45. Porcari JP, Hendrickson TL, Walter PR, Terry L, Walsko G. The physiological responses to walking with and without power poles on treadmill exercise. *Res. Q. Exerc. Sci*. 1997;68(2):161-166.

46. Resnick B, Spellbring AM. Understanding what motivates older adults to exercise. *J. Gerontol. Nurs.* 2000;26(3):34-42.

47. Rippe JM, Ward A, Porcari JP, Freedson PS. Walking for health and fitness. *JAMA*. 1988;259(18):2720-2724.

48. Rodgers CD, VanHeest JL, Schachter CL. Energy expenditure during sub maximal walking with exerstriders. *Med. Sci. Sports Exerc*. 1995;27(4):607-611.

49. Rogers ME, Sherwood HS, Rogers NL, Bohlken RM. Effects of dumbbell and elastic band training on physical function in older inner-city African-American women. *Women Health.* 2002;36(4):33-41.

50. Ross R, Dagnone D, Jones PJH, Smith H, Paddags A, Hudson R, Janssen I. Reduction in obesity and related comorbid conditions after diet-reduced weight loss or exercise-induced weight loss in men. *Ann. Intern. Med*. 2000;133:92-103.

51. Schmidt WD, Biwer CJ, Kalscheuer LK. Effects of long versus short bout exercise on fitness and weight loss in overweight females. *J. Am. Coll. Nutr*. 2001;20(5):494-501.

52. Schneider DA, McLellan TM, Gass GC. Plasma catecholamine and blood lactate responses to incremental arm and leg exercise. *Med. Sci. Sports Exerc.* 2000;32(3):608-613.

53. Spelman CC, Pate RR, Macera CA, Ward DS. Self-selected exercise intensity of habitual walkers. *Med. Sci. Sports. Exerc.* 1993;25(10):1174-1179.

54. Tordi N, Belli A, Mougin F, Rouillon JD, Gimenez M. Specific and transfer effects induced by arm or leg training. *Int. J. Sports. Med*. 2001;22(7):517-524.

55. Van Aggel-Leijssen DPC, Saris WHM, Wagenmakers AJM, Senden JM, Van Baak MA. Effect of exercise training at different intensities on fat metabolism of obese men. *J. Appl. Physiol*. 2002;92:1300-1309.

56. Walter PR, Porcari JP, Brice G, Terry L. Acute responses to using walking poles in patients with coronary artery disease. *J. Cardiopulm. Rehabil.* 1996;16(4):245-50.

57. Wei M, Kampert JB, Barlow CE, Nichaman MZ, Gibbons LW, Paffenbarger RS, Blair SN. Relationship between low cardiorespiratory fitness and mortality in normal-weight, overweight, and obese men. *JAMA*. 1999;282(16):1547-1553.

58. Willson J, Torry MR, Decker MJ, Kernozek T, Steadman JR. Effects of walking poles on lower extremity gait mechanics. *Med. Sci. Sports Exerc*. 2001;33(1):142-147.

59. Zarandona JE, Nelson AG, Conlee RK, Fisher AG. Physiological responses to hand-carried weights. *Phys. Sports. Med.* 1986;14(10):113-114;119-120.

60. Zedaker JM, Naser L, Porcari JP. Physiological responses to walking and running with a powerbelt. *Med. Sci. Sports Exerc*. 1998;30(Suppl.):S168.

APPENDIX

Raw Data during Pre and Post Testing

The following tables show participants' raw data during pre and post testing.

* = Lactate threshold could not be determined
" = Not applicable

P# = Participant number
W = Walking group
P = Powerbelt™ group

Pre = Pretest
Post = Posttest

$\dot{V}O_2$max = Maximum oxygen consumption
HRmax = Maximum heart rate
VEmax = Maximum ventilation
RERmax = Maximum respiratory exchange ratio

% $\dot{V}O_2$max LT = Percent of maximum oxygen consumption at lactate threshold
RER LT = Respiratory exchange ratio at lactate threshold
HR LT = Heart rate at lactate threshold
$\dot{V}O_2$ LT = Oxygen consumption at lactate threshold
VE LT = Ventilation at lactate threshold
Lactate LT = Lactate at lactate threshold
RPE LT = Rating of perceived exertion at lactate threshold

BM = Body mass
BMI = Body mass index
%BF = Percent body fat
Thigh Sk = Thigh skinfold
Abd Sk = Abdomen skinfold
Supra Sk = Suprailiac skinfold

P#	Group	Test	$\dot{V}O_2$max (ml/kg/min)	% $\dot{V}O_2$max LT (ml/kg/min)	HRmax (bpm)	VEmax (L/min)	RERmax	RER LT
1	W	Pre	20.7	*	160	43.8	1.00	*
		Post	25.8	*	178	65.2	1.18	*
2	P	Pre	40.3	48.7	187	131.0	1.25	0.98
		Post	50.1	67.5	186	157.3	1.19	0.96
3	W	Pre	30.0	59.0	202	120.6	1.27	0.96
		Post	32.5	65.5	202	118.0	1.27	1.02
4	P	Pre	33.8	57.1	188	95.4	1.09	0.88
		Post	38.0	70.0	181	100.5	1.07	0.94
5	W	Pre	24.4	59.0	186	95.9	1.21	0.83
		Post	28.2	65.0	191	96.8	1.12	0.90
6	P	Pre	33.9	73.0	204	106.9	1.19	1.01
		Post	35.3	71.0	202	100.1	1.14	0.99
7	W	Pre	25.8	*	192	95.0	1.23	*
		Post	30.1	*	192	97.6	1.11	*
8	W	Pre	37.0	75.0	189	110.0	1.08	0.96
		Post	37.1	77.6	182	102.0	1.14	0.95
9	P	Pre	20.2	*	191	69.2	1.15	*
		Post	22.0	*	180	63.4	1.15	*
10	W	Pre	27.5	69.0	183	89.6	1.16	1.05
		Post	31.2	74.0	186	106.2	1.20	0.95
11	W	Pre	39.7	51.0	203	113.4	1.20	0.85
		Post	43.5	75.0	198	118.9	1.14	0.97
12	P	Pre	25.9	62.0	187	90.4	1.27	1.00
		Post	29.4	58.4	192	110.4	1.22	0.89
13	W	Pre	29.8	*	170	93.7	1.19	*
		Post	33.6	*	169	111.6	1.22	*
14	P	Pre	31.1	61.0	212	122.7	1.23	1.00
		Post	34.1	61.0	219	149.5	1.26	0.99
15	P	Pre	32.2	58.4	189	98.7	1.19	0.95
		Post	34.1	80.7	174	102.6	1.26	1.00
16	P	Pre	28.1	73.3	206	74.7	1.23	0.99
		Post	31.7	73.5	196	66.8	1.21	0.94
17	W	Pre	24.1	59.0	188	109.0	1.22	0.88
		Post	27.7	61.0	182	128.0	1.24	0.88
18	P	Pre	27.8	77.0	198	86.8	1.22	0.96
		Post	30.1	73.4	191	94.8	1.21	0.95
19	P	Pre	25.0	70.0	191	85.0	1.16	0.92
		Post	26.7	68.9	186	85.7	1.15	0.89
20	P	Pre	39.0	66.0	170	87.3	1.14	0.96
		Post	39.0	82.8	169	84.5	1.14	0.95
21	W	Pre	31.8	68.0	195	105.5	1.26	1.01
		Post	37.8	78.8	191	105.5	1.13	0.95
22	W	Pre	23.7	70.9	180	53.5	1.10	0.92
		Post	26.3	79.1	182	56.7	1.05	0.90
23	W	Pre	33.9	56.0	192	114.3	1.16	0.92
		Post	31.9	70.2	190	104.2	1.19	0.89
24	P	Pre	28.3	72.0	178	81.3	1.15	0.95
		Post	31.1	76.2	162	87.0	1.14	0.92

P#	Group	Test	HR LT (bpm)	$\dot{V}O_2$ LT (ml/Kg/min)	VE LT (L/min)	Lactate LT (Mmol)	BM (kg)	Height (cm)
1	W	Pre	*	*	*	*	62.6	152
		Post	*	*	*	*	61.3	152
2	P	Pre	127	19.6	40.9	3.2	78.9	175
		Post	146	33.8	72.6	3.2	76.0	175
3	W	Pre	148	17.7	45.7	2.2	89.8	170
		Post	156	21.3	56.5	3.2	88.9	170
4	P	Pre	139	19.3	45.2	3.3	73.3	170
		Post	155	26.7	61.6	2.6	72.4	170
5	W	Pre	121	13.4	29.6	4.0	85.3	168
		Post	147	18.4	43.4	3.2	85.5	168
6	P	Pre	166	24.7	61.5	3.9	80.0	165
		Post	163	25.1	61.7	4.7	78.5	165
7	W	Pre	*	*	*	*	84.4	173
		Post	*	*	*	*	84.4	173
8	W	Pre	160	27.8	68.7	2.7	94.4	172
		Post	147	28.8	69.7	2.5	91.9	172
9	P	Pre	*	*	*	*	77.7	162
		Post	*	*	*	*	76.0	162
10	W	Pre	158	18.9	53.4	2.9	83.0	166
		Post	159	23.1	62.5	2.6	82.6	166
11	W	Pre	126	20.4	40.1	2.0	93.4	182
		Post	177	32.6	69.2	3.3	91.4	182
12	P	Pre	135	16.0	40.3	2.1	77.5	165
		Post	138	17.2	35.2	1.6	73.9	165
13	W	Pre	*	*	*	*	79.4	171
		Post	*	*	*	*	81.7	171
14	P	Pre	159	19.1	48.9	3.0	98.2	174
		Post	170	20.9	56.0	2.8	101.2	174
15	P	Pre	144	18.8	41.1	2.7	87.8	175
		Post	151	27.5	65.3	4.1	85.5	175
16	P	Pre	180	20.6	38.6	2.8	65.0	157
		Post	168	23.3	37.9	3.7	63.3	157
17	W	Pre	137	14.3	41.2	3.8	110.5	175
		Post	141	16.9	47.1	4.1	111.6	175
18	P	Pre	174	21.4	44.5	3.0	68.4	162
		Post	155	22.1	44.5	3.4	68.5	162
19	P	Pre	141	17.5	42.0	3.4	82.6	164
		Post	146	18.4	46.7	3.3	82.3	164
20	P	Pre	136	25.7	44.7	3.1	69.6	160
		Post	144	32.3	58.3	2.9	70.3	160
21	W	Pre	167	21.5	50.5	3.2	65.8	158
		Post	174	29.8	63.9	4.1	63.5	158
22	W	Pre	161	16.8	31.7	1.8	71.9	159
		Post	163	20.8	38.8	2.1	71.9	159
23	W	Pre	143	19.1	44.8	3.2	95.9	170
		Post	156	22.4	53.5	3.1	95.9	170
24	P	Pre	142	20.5	44.8	2.7	76.2	164
		Post	141	23.7	50.2	2.7	76.9	164

P#	Group	Test	BMI	%BF	Thigh Sk (mm)	Abd Sk (mm)	Supra Sk (mm)	RPE LT
1	W	Pre	27.1	36.7	43.7	"	19.8	*
		Post	26.5	38.2	43.1	"	20.6	*
2	P	Pre	25.8	22.4	22.8	43.4	"	12
		Post	24.8	17.9	15.2	30.2	"	14
3	W	Pre	32.0	25.5	27.5	37.9	"	13
		Post	30.8	25.7	28.2	34.2	"	8
4	P	Pre	25.4	33.2	44.8	"	17.7	13
		Post	25.0	30.9	38.6	"	17.8	11
5	W	Pre	30.2	27.9	27.6	"	18.7	11
		Post	30.3	34.0	32.5	"	28.2	11
6	P	Pre	29.4	29.4	27.0	"	19.3	16
		Post	28.9	31.4	28.7	"	25.7	12
7	W	Pre	28.2	31.3	45.5	"	17.4	*
		Post	28.2	32.9	46.2	"	21.7	*
8	W	Pre	31.9	27.1	21.6	44.2	"	15
		Post	31.0	24.2	17.6	37.2	"	10
9	P	Pre	29.7	45.8	68.8	"	22.9	*
		Post	29.0	43.5	60.5	"	21.1	*
10	W	Pre	30.1	45.3	69.0	"	30.0	14
		Post	30.0	43.8	60.2	"	33.3	12
11	W	Pre	28.2	22.2	13.7	43.7	"	14
		Post	27.6	19.6	11.5	36.9	"	13
12	P	Pre	28.5	38.1	48.9	"	21.0	19
		Post	27.2	35.5	39.6	"	21.6	11
13	W	Pre	27.2	25.9	18.8	34.2	"	*
		Post	28.0	26.8	18.5	33.6	"	*
14	P	Pre	32.4	25.7	27.9	31.7	"	13
		Post	33.4	26.2	29.6	29.7	"	8
15	P	Pre	28.7	26.6	18.9	38.4	"	13
		Post	27.9	22.5	16.3	32.4	"	11
16	P	Pre	26.4	31.2	38.9	"	15.4	14
		Post	25.7	28.3	36.3	"	12.9	10
17	W	Pre	36.1	38.5	44.3	56.6	"	11
		Post	36.5	33.1	34.0	47.8	"	11
18	P	Pre	26.1	30.3	40.7	"	11.2	12
		Post	26.1	30.3	38.9	"	13.5	10
19	P	Pre	30.7	28.2	24.4	40.0	"	8
		Post	30.6	25.2	20.0	36.5	"	12
20	P	Pre	27.2	30.3	37.3	"	17.9	12
		Post	27.5	28.8	35.6	"	16.2	15
21	W	Pre	26.3	24.5	19.9	"	19.9	11
		Post	25.4	21.9	17.8	"	15.4	10
22	W	Pre	28.4	36.1	31.0	"	29.9	15
		Post	28.4	34.4	31.4	"	26.0	12
23	W	Pre	33.4	29.8	12.4	"	33.5	11
		Post	33.4	28.3	12.5	"	35.7	13
24	P	Pre	28.3	27.4	24.8	"	19.4	14
		Post	28.6	25.9	25.8	"	18.4	12