

ABSTRACT

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86 sedentary women ranging in age from 20 to 50 ($X = 37$ yrs) were randomly placed in a walking ($W = 30$), exerstriding ($ES = 29$), or control ($C = 27$) group. All Ss completed a walking VO_{2max} test prior to and after completing a 12 week walking program. Metabolic responses were obtained each min throughout the treadmill tests using standard open-circuit techniques. HR and RPE were also obtained throughout the tests. Both W and ES trained for 30-45 min per day, 4 days per week at 70-85% of max HR. In addition, the ES group used rubber tipped walking sticks (Exerstriders) to supplement their traditional walking workout. None of the C group's physiological responses to the VO_{2max} tests were significantly ($p > .05$) altered. A slight increase ($p < .05$) in max V_E occurred from pre- to posttesting in E, but not the W group. VO_{2max} significantly ($p < .01$) increased by 7.6% (36.5 to 39.5 $mlO_2 \cdot kg^{-1} \cdot min^{-1}$) for the W and 7.7% (33.7 to 36.5 $ml \cdot kg^{-1} \cdot min^{-1}$) for ES. Treadmill time significantly ($p < .01$) increased by 17.9 and 20.7% in ES and W, respectively. No difference in the changes between the ES and W groups existed. There were no significant ($p > .05$) differences in max R value, HR, or RPE for either groups. Both groups exercised at the same intensity, but the Exerstriders walked significantly ($p < .05$) slower than the walkers. Both walking and using Exerstriders provide a sufficient training stimulus to increase aerobic performance in previously sedentary women. The physiological benefits of Exerstriding can occur at a lesser training speed and shorter distance traversed compared to walking.

AEROBIC RESPONSES TO 12 WEEKS OF
EXERSTRIDING OR WALKING TRAINING IN
SEDENTARY ADULT WOMEN

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DEDICATION

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CHAPTER I

INTRODUCTION

The popularity of aerobic exercise is continually growing. More and more people of all ages exercise to maintain health. Walking specifically has been the focus of much attention. Indeed, walking as a mode of exercise has been shown to have a beneficial effect on the cardiovascular system and body as a whole (Flint, Drinkwater, & Horvath, 1974; Porcari et al., 1986; Schultz, 1980).

Humans, because of their bipedal stature, do not completely utilize their upper body musculature during the process of walking and/or running. Because of this, cross country skiing, which necessitates using the arms and legs simultaneously to propel the body, has gained an enviable reputation as one of the best all around aerobic exercises available (Hanson, 1973; Ng et al., 1988; Simard & Roy, 1979). According to the American College of Sports Medicine's position statement (ACSM, 1990) any mode of activity that incorporates large muscle groups, is rhythmically performed, and maintained at a continuous pace, is considered appropriate for enhancing cardiorespiratory fitness. Cross country skiing certainly matches that description and theoretically would provide a more thorough,

whole-body mode of exercise compared to walking, running, or biking in which the arms are "going along for the ride".

According to Exerstrider Products Inc., a whole-body workout similar to that attained via cross country skiing can be experienced through the use of Exerstriders. Exerstriders are, simply stated, walking sticks or modified ski poles (i.e., modified in the sense that instead of pointed tips, rubberized tips are used). Exerstriders are used to supplement a walking workout. With each step taken, a force is exerted alternately through the Exerstrider pole in a patterned motion similar to cross country skiing. Exerstriding is best done on a dry smooth surface (not snow), so there is no gliding motion as with traditional skiing. In previous research on the use of Exerstriders (Babyak, Van Heest, & Rodgers, 1991), the benefits of this mode of exercise were apparent. Significant increases in VO_2 cost, heart rate, total kilocalories expended, and RER were reported during treadmill exercise using Exerstriders versus walking at a submaximal intensity of 60% of maximal heart rate. These authors speculated that the increases in physiological responses were due to the increased upper body muscle mass utilized during Exerstriding.

Beyond the metabolic and physiological effects of this exercise mode, there is the additional benefit of being a low impact form of exercise. During the process of

Exerstriding there is a low level of foot pounding compared to running. This, theoretically, would cause fewer injuries to joints, ligaments, and muscles. These benefits would be desirable to persons of all ages and fitness levels from the beginning exerciser, elderly, or obese, to the conditioned athlete.

Need for the Study

It is well known that walking, in and of itself, has been shown to be an effective mode of exercise (Luria & Koepke, 1975; Porcari et al., 1986; Schultz, 1980). In addition, many studies have looked at aerobic exercise incorporating upper body muscle mass during exercise (MacDougall, Hughson, Sutton, & Moroz, 1979; Millerhagen, Kelly, & Murphy, 1983; Stamford, 1984; Toner, Sawka, Levine, & Pandolf, 1983). These aforementioned studies investigated various ways of incorporating upper body involvement using such methods as cross country skiing, cross country ski simulation, arm ergometry, and use of hand weights, respectively, during aerobic exercise.

The literature on Exerstriding is extremely limited due to the fact that it is a new form of exercise. The public is not fully aware of what Exerstriding is and the benefits that can be derived from it. No training studies have been done to examine the effects of Exerstriding. The results of this study will provide exercise specialists with valuable

information regarding the uses and physiological/physical benefits of this low impact aerobic exercise. The information and results will also be valuable in providing the basis for an exercise prescription in adult fitness programs or Phase IV cardiac rehabilitation patients.

Statement of the Problem

The purpose of this study was to compare the training effects of 12 weeks of walking while using poles (Exerstriders), to 12 weeks of traditional walking training.

Assumptions

The following assumptions were made:

1. Subjects followed directions properly throughout the entire study.
2. Each subject was able to quickly and accurately monitor her heart rate as instructed during the first week of training, and maintain that heart rate within her individualized training heart rate range.
3. Each subject truthfully answered her initial screening questionnaire regarding her individual personal exercise habits.
4. Dietary habits of all subjects did not change throughout the course of the study.
5. Subjects in the Exerstrider group maintained proper form and technique during each training period.

6. Subjects in the control group maintained their normal exercise habits during the course of the study.

Null Hypotheses

There will be no significant differences in maximal VO_2 , heart rate, R value, treadmill time, ventilation, and RPE among the Exerstrider, walking, and control groups as a result of training an average of 4 days per week for 12 weeks for a total of 48 exercise sessions.

Delimitations

Delimitations of the study were as follows:

1. Subject selection was delimited to 87 healthy, sedentary, female volunteers who responded appropriately to a phone screening questionnaire (PAR-Q) form (see Appendix A).
2. The training period was delimited to 4 days per week, 12 weeks in duration.

Limitations

The following were limitations of the study:

1. A true representation of the population may not have been displayed in the sample of subjects, as many participants were volunteers and not a random sampling.
2. The efficiency and coordination of the Exerstriders and/or walkers which was acquired with practice was an unmeasurable variable.

Definition of Terms

The following terms were used in this study:

Body Weight - the number of kilograms each subject weighed prior to pre- or posttesting.

Duration - the number of minutes spent exercising per session.

Exerstriders - modified ski poles or walking sticks with rubberized tips, used concurrently while walking. While using Exerstrider poles, upper body muscle mass is incorporated during a walking workout.

Frequency - the number of sessions per week each subject exercised.

Intensity - the level of physical exertion performed, and was determined by maintaining a given pulse rate at a specified percentage of maximal heart rate.

HRmax - the highest heart rate attained during VO_{2max} testing.

Maximal Treadmill Test - a modified Balke walking protocol (see Appendix B) was used which stressed the cardiovascular system incrementally via an increase in grade/workload of 2.5% every 2 minutes at a constant self-selected walking speed between 3.25 and 4.00 mph until a symptom limited maximal effort was reached. At this point, the subject was unable to continue, and the test was terminated.

MET - one MET is the amount of oxygen needed by the body to maintain resting bodily functions and is approximately $3.5 \text{ mlO}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$. Exercise intensity can be stated in MET units by measuring $\text{VO}_{2\text{max}}$ ($\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) and dividing this value by one MET ($3.5 \text{ mlO}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$).

RPE - rating of perceived exertion is a rating or opinion (on a scale of 6-20) of how difficult, overall, the intensity of exercise is on any given exercise bout (see Appendix C). Borg (1982, p. 377) stated that "RPE is the single best indicator of the degree of physical strain".

R Value - the ratio of CO_2 produced to O_2 consumed as measured at the lung level. This value gives an indirect cumulative representation of all cellular respiratory processes occurring at the instance of measurement.

Sedentary Lifestyle - a state of physical fitness in which subjects exercised no more than 1-2 sessions per week for 20-30 during the past 6 months.

Treadmill Time - the duration of time (minutes) in which subjects walked during maximal treadmill testing.

Maximal Ventilation - the maximum amount of air breathed (in liters per minute) at maximal exertion during maximal treadmill testing.

$\text{VO}_{2\text{max}}$ - the maximum amount of oxygen consumption during maximal exertion. Specifically, it is that point during the modified Balke treadmill protocol where an increase in grade

did not result in an increase ($> 2.1 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) in oxygen consumption (Taylor, Buskirk, & Henschel, 1955) and/or the R value was greater than 1.0.

CHAPTER II

RELATED LITERATURE

Introduction

The growing interest in exercise and health has increased the production of exercise equipment. The list of new exercise equipment currently on the market seems endless. Research involving Exerstriding is not very extensive at this time. However, research has been completed involving related activities (i.e., walking, cross country skiing, with its similar arm motions, and various other upper body exercises).

This chapter first reviews research involving the physiological effects of cardiorespiratory fitness and conditioning in general. Later sections deal with specific types of training: walking, followed by aerobic activities utilizing the upper body.

Cardiorespiratory Fitness

Definition

Every cell in the human body needs oxygen to function properly. The ability, or inability, of the body to take in and distribute oxygen is an indicator of overall fitness. According to Wasserman and Whipp (1975), the body's ability to take in and deliver oxygen is dependent on three systems.

First, the respiratory system must effectively extract oxygen during breathing and carry it to the bloodstream. Second, the cardiovascular system must effectively pump the oxygenated blood throughout the systemic circulation. Third, the muscles and tissues must be able to utilize the delivered oxygen during physical work. This highly simplified description forms the basis of general cardiorespiratory fitness. The cardiovascular system, the respiratory system, and musculoskeletal system all must interact cooperatively to perform physical activity.

The more physically fit an individual is, the more oxygen they can take in and distribute throughout the body. The ACSM Position Statement (1990) indicates that fitness is dependent upon (changes in) $VO_2\text{max}$, muscular strength and endurance, and body composition. They stated fitness is the ability of the body to do moderate or vigorous work intensities throughout the entire lifespan without excessive fatigue.

$VO_2\text{max}$

$VO_2\text{max}$ (where V is volume per minute, O_2 is oxygen, and max signifies maximal or highest level), is the highest amount of oxygen that the body can use in a minute (Holly, 1988). According to Martin, Notelovitz, Fields, and O'Kroy (1989), and the ACSM (1990), $VO_2\text{max}$ is the best indicator of

cardiorespiratory fitness. It is usually expressed in absolute terms as $\text{LO}_2 \cdot \text{min}^{-1}$, or relative to weight as $\text{mlO}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$.

Wasserman and Whipp (1975) stated that as the work rate on a treadmill or cycle ergometer gradually increases, so does the volume of oxygen used or VO_2 . This increasing work rate and accompanying increase in VO_2 can continue until the individual reaches their maximal ability, at which time the VO_2 plateaus, and the individual cannot continue to work. At this point, $\text{VO}_{2\text{max}}$ is reached.

Since most people are familiar with and capable of walking or running, these activities are frequently used to determine an individual's $\text{VO}_{2\text{max}}$. When Taylor et al. (1955) studied $\text{VO}_{2\text{max}}$, they found that incrementally increasing treadmill grade by 2.5% while maintaining speed at 7.0 mph were optimum conditions for achieving $\text{VO}_{2\text{max}}$. Each 2.5% increase in grade yielded roughly a $300 \text{ ml} \cdot \text{min}^{-1}$ increase in VO_2 .

Since then many treadmill protocols have been developed to measure an individual's $\text{VO}_{2\text{max}}$. Uphill treadmill exercise tends to produce the highest $\text{VO}_{2\text{max}}$ values in the general population. Some of the most commonly used treadmill walking protocols are the Balke, modified Balke, and Naughton protocols (Hanson, 1988, p. 210). The Balke and Naughton protocols use a constant walking speed of 3.3

and 2.2 mph, respectively, as the grade is increased every 2 or 3 minutes by 2.0 to 3.0% until maximal exertion is reached. The modified Balke uses a self-selected walking speed that is brisk, yet comfortably suited to each subject (Ebbeling, Ward, Puleo, Widrick, & Rippe, 1991). During this test the grade is increased 2.5% every 2 minutes. Walking protocols are used most often with untrained subjects due to the gradual increase in workload.

Taylor et al. (1955) considered $\text{VO}_{2\text{max}}$ to be the point where an oxygen uptake of $150 \text{ ml}\cdot\text{min}^{-1}$ or less was seen between two different grades, or an oxygen uptake of $2.1 \text{ ml}\cdot\text{kg}^{-1}$ or less per minute. Ebbeling et al. (1991) suggested that to achieve $\text{VO}_{2\text{max}}$ one of the following criteria had to be met: 1) a leveling off in oxygen consumption despite an increased workload, 2) attainment of a maximal heart rate within 15 beats per minute of their age predicted maximal heart, and 3) an R value greater than or equal to 1.10. Millerhagen et al. (1983) considered $\text{VO}_{2\text{max}}$ to be the point where VO_2 displayed a leveling off (i.e., an O_2 uptake of less than $200 \text{ ml}\cdot\text{min}^{-1}$ from the next to the last exercise stage). In research by Weltman et al. (1989), maximal VO_2 was chosen as the highest VO_2 attained. Lastly, Black, Ribeiro, and Bochesse (1984) used an R value criterion measure of 1.0 to indicate maximal aerobic metabolism. Interestingly, U.S. nordic ski team members who displayed

VO₂max values of 88.3 and 78.8 ml·kg⁻¹·min⁻¹ attained R values of 1.03 and 0.95, respectively (Hanson, 1973). the value of 88.3 ml·kg⁻¹·min⁻¹ was, at the time, the highest level attained for relative VO₂max in the literature.

Training

Several factors must be taken into consideration when devising any training program to develop cardiorespiratory fitness. One of the basic requirements is that an overload to the system must be applied. This is done via gradually incremented exercise of varied intensity, duration, and frequency (McArdle, Katch, & Katch, 1986, p.348). In addition, the initial fitness level of the subject plays a role in the training process. If a low fitness level is initially present, greater improvements will be seen as compared to someone who is fit initially. Sharkey (1970) found that improvements in fitness displayed a highly significant negative correlation relative to the individual's initial level of fitness.

Mode. According to the ACSM position statement (1990), exercises which incorporate the larger muscle groups on a continual and rhythmic basis are preferred. Examples of such exercises are walking, running, swimming, cycling, Exerstriding, etc.

Intensity. The ACSM (1990) recommends that an overload be applied to the cardiovascular system, such as 60-90% of

maximum heart rate or 50-85% of VO_{2max} or heart rate reserve, to produce a training response.

Kearney, Stull, Ewing, and Strein (1976) found that training at an exercise heart rate of 65% of heart rate reserve (HRR) showed no additional gains over exercising at 50% of HRR. Both intensities elicited increases in VO_{2max} suggesting that an individual can gain improvements at lower intensity levels.

Edwards (1974) wanted to determine what intensity is necessary for eliciting cardiovascular changes. Her subjects trained on a treadmill for 15 minutes every day for 4 weeks. One group of women exercised at an intensity of 125 bpm and another group at 145 bpm. It was found that working as low as 125 bpm produced a training effect. Edwards considered this intensity was more than a minimal intensity to obtain a training effect.

Frequency. A training frequency refers to how often exercise is done. Exercise guidelines suggested by ACSM (1990) recommend that exercise be done 3-5 days per week to develop improvement in VO_{2max} values. Exercising more than 5 times per week did not proportionally improve VO_{2max} .

Once a desired state of fitness has been reached, a reduced training frequency can maintain that level. For example, a group of subjects trained in both cycling and running 6 days per week, 40 minutes per day, for 10 weeks

(Hickson & Rosenkoetter, 1981). After 10 weeks, half reduced their training to 4 days, and the other group 2 days per week for another 15 weeks. $\text{VO}_{2\text{max}}$ was maintained equally by both groups.

In an investigation by Brynteson and Sinning (1973), a 5 week cycling program, at 80% maximum heart rate, 5 days per week, improved aerobic fitness. That level was retained for at least 5 weeks when the frequency was reduced to 3 times per week at the same intensity.

Duration. There is an interrelationship between duration and intensity (McArdle et al., 1986, p.358). For example, when a low intensity exercise is performed, a longer duration of 45-65 minutes is necessary to produce a training effect. When a higher intensity is used, a duration of perhaps 15-20 minutes is all that is necessary to elicit a training effect. Recent ACSM (1990) guidelines suggest that 20-60 minutes of continuous exercise be carried out. However, the higher the intensity, the more likely that overuse injuries will occur. Therefore, a moderate intensity of longer duration is suggested for most individuals. Training, for those individuals whose primary goal is to lose weight, should emphasize increased caloric expenditure. This is best done by exercising at low to moderate intensities. However, regimens of increased frequency and duration should be done.

The most important factor in any training program is to gradually increase the intensity and duration of the exercise until the desired training effect is achieved.

Arm Ergometry

When comparing arm cranking, leg cycling, and arm cranking combined with leg cycling, there was an increase in $VO_2\text{max}$ when the proportion of total work done involved use of the arms (Toner et al., 1983). They concluded that the increase in $VO_2\text{max}$ with arm work was due to the need for stabilization of the body during combined arm cranking and leg cycling.

During exercise on an air-braked, push-pull cycle ergometer, subjects had lower maximum heart rates when "arms only" were used (Nagle, Richie, & Giese, 1984). The subjects' maximum heart rates were the highest when 10% arms and 90% legs were used. These authors suggested that when the legs do most of the work, there would be an increased venous return. This increased venous return would, therefore, cause an increased atrial filling and also an increased end diastolic volume leading to an accelerated heart rate. Their experiment indicated that adding arms to leg exercise, in this case during air-braked cycle ergometry, lead to an increased $VO_2\text{max}$.

When Franklin (1989) studied unfit individuals, he found that upper body aerobic training could lead to

improvements in cardiac output, stroke volume, and $A-VO_2$ difference. These changes would lead to increases in peak VO_2 during combined arm and leg exercise. Franklin warned, however, that basing an arm exercise prescription heart rate from a maximal leg exercise test may be erroneously high. He suggested that a resistance that is acceptable for leg ergometry should be decreased by at least 50-60% for arm ergometry.

Pate, Hughes, Chandler, and Ratliffe (1978) trained a group of subjects for 8 weeks via conventional cycle ergometry. After cycle training ceased, the subjects then performed only arm ergometry for 4 weeks. They found that arm training alone did not have a significant effect on the decline in fitness initially attained via cycle ergometry. Simply stated, fitness levels decreased even though arm training was still being done.

Cross Country Skiing/Simulation

Numerous reasons for enhanced VO_{2max} values of cross country skiers are provided in the literature. Cross country skiing, and its corresponding method of arm poling, uses upper body musculature to propel the body forward. This exercise mode leads to a higher oxygen cost compared to running, which mainly uses only the legs (MacDougall et al., 1979). In addition, the weight of the equipment used added an average of an extra 5.4 kg, thus adding to the oxygen

cost. MacDougall and colleagues also found that oxygen consumption using the double poling technique (i.e., using both arms simultaneously rather than alternately) was higher than during the diagonal striding technique among elite competitors.

Even in the elderly, cross country skiing has been shown to be effective in increasing overall fitness (Simard & Roy, 1979). These researchers studied 80 men and women between 60-75 years of age. The experimental group skied 3 times per week, 60 minutes per session, at an average heart rate of 120 beats per minute. VO_2max increased significantly from 24 to 30 $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, hematocrit increased, and body weight (in females) decreased as well.

Performance data collected on 7 U.S. Nordic Ski Team members indicated physiological values which were similar to the world's highest published values (Hanson, 1973). VO_2max values greater than 6.0 $\text{L}\cdot\text{min}^{-1}$ (88 $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) were attained due to well developed cardiorespiratory systems, muscular strength and coordination, technique, as well as psychological factors in these competitive skiers.

When Bergh (1987) studied a group of world class cross country skiers, he found significantly higher oxygen uptakes in the world class athletes compared to their less successful counterparts. Bergh suggested that if VO_2max was

below $83.8 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, chances of winning an Olympic gold medal were drastically reduced.

When studying 43 (44 year old) male citizen cross country skiers (defined as uncoached, and not a participant of a sponsored team) taken from the general population, Ng et al. (1988) found $\text{VO}_{2\text{max}}$ values to be $56.6 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, and average percent body fat to be 10.1%. They considered these subjects to be a rather fit subgroup of the population.

In a simulated cross country skiing study, an analysis of combined arm and leg work, leg work only, and arm work only was done (Millerhagen et al., 1983). Anaerobic threshold was significantly delayed in the combined arm and leg trial and RPE values were lower in the combined arm and leg trial. Upper body muscle mass utilization may have delayed some of the fatigue within the legs physically and perceptually. In addition, it was found that the subjects naturally chose 18-26% of the total effort to be done by the arms.

Exerstriding

Recently, Babyak et al. (1991) studied 10 females of moderate fitness level who averaged 23.6 years of age. They performed two trials on the treadmill, one without Exerstrider poles, and one with Exerstrider poles. Both groups exercised at 4.2 mph, 0% grade, for 30 minutes at 60%

of maximum heart rate. The trial using the Exerstrider poles elicited a significantly higher VO_2 cost as compared to walking (i.e., $20.5 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ versus $18.3 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, respectively). Heart rates, kcals consumed, and R-values were significantly higher while using Exerstrider poles as compared to walking. Babyak et al. suggested that these increases were due to the increased upper body muscle mass utilized during the Exerstrider trial.

Other Upper Body Aerobic Exercise

Joseph Wassersug, M.D., in an interview with Rogers (1986, p. 182), stated that "Society has put a bizarre emphasis on jogging. Leg exercise may seem more vigorous than arm exercise, but it is not enough, plus jogging causes far too many injuries". In addition (Rogers, 1986, p. 185), Bernard Gutin, Ph.D. stated, "Although I oppose the idea that you can get a good workout in your armchair, we have overdone it with aerobic exercise (using legs only). We're finally getting away from the idea that running is the only thing you need to do". Indeed, the idea that is portrayed by these two experts is that if walking or jogging can increase fitness levels, then adding a contribution from the upper body can only enhance the overall objective, (i.e., improved cardiorespiratory fitness).

Lewis et al. (1983) reported that cardiovascular responses are largely determined by the amount of active

muscle mass used during exercise. When a larger muscle mass was used, heart rates were increased at any given VO_2max , there was a lower systemic resistance, and higher catecholamine levels. This agrees with earlier research done by Taylor et al. (1955) who found VO_2max was increased when the upper body muscle mass was simultaneously incorporated into a running workout.

Central circulation and peripheral circulation were the focus of Clausen, Klausen, Rasmussen, and Trap-Jensen's (1973) research. They discovered that the upper body, and arms specifically, have better local circulation adaptability, whereas central circulation adaptability occurs more readily when more muscle mass (the legs in this case) was used.

Bergh, Kanstrup, and Ekblom (1976) also found that VO_2max was dependent on the amount of muscle mass utilized. They stated that exercise at any given work rate can be maintained for longer periods of time during arm and leg exercise combined versus leg only cycling. They suggest the optimum arm workload for increasing VO_2max was a subjective selection of 18-26% of total work done with the arms.

During a 6 week study involving exercise 3 times per week, one half of the subjects exercised with arms and legs while the other half used legs only during cycle ergometry (Mostardi, Gandee, & Norris, 1981). Individuals in the

combined arm and leg group did more total work per training session, but at a lower heart rate. These results illustrated the concept that the heart and musculoskeletal system received less stress when both upper and lower body are used. They concluded that combined arm and leg exercise is beneficial for any individual, but would be ideal for cardiac patients due to the decreased demand to the myocardium at a given work rate.

Research on Hand Held Weights

There is substantial evidence indicating that exercising while holding hand weights can incorporate the upper body musculature enough to enhance most regular walking or running workouts.

As early as 1969, Soule and Goldman indicated that the energy cost of weights carried by the hands was 1.9 times greater than during the no load trial. More recently, Raab, Smith, Smith, and Gilligan (1985) showed that using wrist, waist, or ankle weights caused an increase in energy consumption.

Stamford (1984) indicated that hand or ankle weights used during aerobic exercise are beneficial because they increase the caloric consumption of the activity. Handweights also provide more resistance, thus leading to increased strength gains. Conversely, an increase in weight decreases the subject's speed during activity, and possibly,

the cardiovascular benefits may be lost to gains in strength. In addition, Stamford warned that using excessive arm motions with hand weights is contraindicated due to an increased chance of damage to connective tissue. Stamford states that running with hand weights is ill-advised because the weights magnify the inherent stress of the activity and may interrupt normal cadence and rhythm.

Subjects who carried 3 pound hand weights during treadmill walking displayed a 1 MET increase in metabolic cost compared to normal walking (Graves, Pollock, Montain, Jackson, & O'Keefe, 1987). Also, time to exhaustion was significantly decreased when the hand weights were used. They suggested that hand held weights could be beneficial in an exercise prescription designed for those who cannot run and/or are not able to do fast walking.

Recently, Auble and Schwartz (1991) stated that $VO_2\text{max}$ obtained while exercising with hand weights can significantly exceed the values attained without hand weights. Specifically, the greater the range of motion the weights were swung, the greater the effect on $VO_2\text{max}$. Thus, adding hand weights to traditional walking or running can potentially convert the exercise from being mainly leg dominated, to a total body exercise.

Walking

When many people think of exercising, running immediately comes to mind. What about simply walking to attain a level of fitness? In a survey of 2050 educated, middle class, Caucasians, Hovell et al. (1989) determined most individuals walk specifically for exercise purposes less than an hour per week. In addition, subjects with more exposure to physical education and sports walked the least, while older subjects reported more walking than younger persons. Positive family support and self efficacy were related to higher incidences of walking as an exercise form in this study.

According to Schultz (1980), walking for exercise purposes is beneficial for most individuals, and involves only the use of a good quality pair of shoes. Schultz also emphasized that walking can be done any time, any place, and without equipment, and is as useful as any aerobic activity if done over a long term.

In an early walking study (Pollock et al., 1971), men (\bar{x} = 48.9 yr) trained for 20 weeks, 40 minutes per session, 4 times per week. Most subjects trained between 60 to 70% of maximal heart rate, with others between 80 to 90%. In some subjects, the physical limitations of walking governed the intensity of training more than others. Walking resulted in a increase in VO_2max from 2.30 to 2.94 $\text{L}\cdot\text{min}^{-1}$ or

a 28% improvement. Body weight and percent body fat decreased by 1.3 kg and 1.1%, respectively.

In a study of young (21-28 years) and old (53-61 years) females, VO_2max increased after 7 weeks of walking training by 10.3% in the young group, and by 6.3% in the old group (Kilbom & Astrand, 1971). An intensity of 70% of maximal heart rate was used. Maximum cardiac output increased by 10.5 and 8.7% in the young and old group respectively.

A 6 week training program involving 30 minutes of walking on a treadmill 3 times per week at 75-80% of maximum heart rate was administered by Flint et al. (1974). The subjects, women age 23-49, displayed a 12% increase in VO_2max following completion of this walking program.

Often, a concern that many people/exercisers have regarding a walking program is whether or not the intensity will be adequate for them. Luria and Koepke (1975) felt that walking may not provide a sufficient intensity for people of higher fitness levels, and such individuals may need a more strenuous mode of activity. In contrast, Porcari et al. (1986) tested 217 male and female subjects between the ages of 30-69 years of age. They found that 81% of the males and 86% of the females were able to achieve their appropriate training intensity of 70% of maximum heart rate during walking.

Recently, Ward et al. (1990) demonstrated that increases in VO_2max occurred in response to low intensity (< 50% of HRR), mild intensity (50-54% of HRR), and high intensity (> 55% of HRR) walking. They speculated that walking exercise prescriptions typically given to individuals can be lower in intensity, as compared to traditional intensities of 60 to 80% of heart rate reserve, while still producing aerobic benefits.

According to Porcari et al. (1987), speed is a factor in achieving a training heart rate. In people who achieved a training heart rate, their speed averaged 0.1 to 0.5 mph faster than people who did not reach their training heart rate. Fast walking easily offered an intensity high enough to achieve a training heart rate in people over 50 years of age. As in previous studies, a training heart rate of 70% of VO_2max was less likely to occur in individuals with initially high VO_2max levels. However, even young males with high VO_2max values in Porcari's et al. (1987) study could maintain a training heart rate for more than 30 minutes with fast walking when provided with constant visual feedback of their heart rate. For all levels of fitness, achieving a training heart rate was possible, but involved an increased walking speed.

At speeds of 8-9 km/hr, physiological responses and efficiency of fast walking and running become equal (Hagberg

& Coyle, 1984). Slower walking speeds are more efficient than running however. As with Franklin, Kaimal, Moir, and Hellerstein (1981), they found no difference in VO_2max when comparing runners and racewalkers.

Foster, Hume, Byrnes, Dickinson, and Chatfield (1989) suggested using lower intensity exercise especially at the onset of an exercise program and walking certainly fits that description. In addition, they found that with sedentary women, low intensity walking showed no differences compared to moderate intensity in eliciting a training effect. The women over age 70 increased their VO_2max after 10 weeks of walking at either 40 or 60% of their heart rate reserve. In addition, Luria and Koepke (1975) showed that there is a lower dropout rate in walking programs as compared to more strenuous exercise modes/programs.

Race Walking

Franklin et al. (1981) compared highly trained race walkers with highly trained long distance runners. They discovered that the race walkers were physiologically very similar to the marathon runners. The average VO_2max of the walkers was $62.9 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ compared to $75+ \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ for the marathoners. Training mileage for the walkers averaged 73.9 miles per week at 6.5 to 9.0 mph. Indeed, this fast pace is beyond what most average individuals could maintain for a typical walking workout. From these studies, it

appears that walking can provide the necessary intensity to enhance cardiovascular and other physiological parameters.

Other Benefits

In addition to changes in $VO_2\text{max}$, walking programs have resulted in: 1) enhanced biosynthesis of collagen within skeletal muscle (Suominen, Lic, Heikkinen, & Parkatti, 1977), 2) an increased excess postexercise oxygen consumption or EPOC (Sedlock, Fissinger, & Melby, 1989), and 3) increases in vasodilatory capacity of the distal lower extremities (Martin, Kohrt, Malley, Korte, & Stoltz, 1990).

Summary

The attainment of a desired level of cardiorespiratory fitness is best done by manipulating the frequency, intensity, and duration of exercise. Ideally these variables should elicit the maximum benefit to the exerciser, at the lowest possible risk. The American College of Sports Medicine (1990) suggest that 3-5 exercise sessions be done per week for 20-60 minutes in duration. An intensity of 60-90% of maximal heart rate or 50-85% of $VO_2\text{max}$ (heart rate reserve) should be maintained. Any exercise mode that uses large muscle groups continuously and rhythmically is advised. Walking can be used to meet the above requirements.

Walking as an exercise mode is becoming more and more accepted as a low impact aerobic exercise. Several studies

have indicated that over time, walking provides numerous physiological benefits to the cardiorespiratory system.

Combining upper body aerobic exercise with the lower body, is now being recognized as having an integral place in exercise prescription for beginning and veteran exercisers alike. Upper body exercise modalities such as cross country skiing, arm ergometry, and hand held weights have been the focus of much research. Less is known about the physiological effects of incorporating the upper body musculature through the use of Exerstriding.

CHAPTER III

METHODOLOGY

Introduction

The purpose of this study was to compare the cardiorespiratory effects of a training program on females who either trained for 12 weeks using Exerstriders, walked, or remained sedentary as controls. All subjects completed pre- and posttesting including a maximal treadmill test, hydrostatic weighing, upper body strength and endurance tests, and a "general well being" paper and pencil inventory. This chapter gives information on subject selection, instrumentation, experimental procedures, and statistical treatment of data relating to the maximal treadmill test results only.

Subject Selection

To obtain participants, a newspaper advertisement was run for a 3 day period. In addition, posters were placed throughout the local area on public bulletin boards announcing a need of subjects for the study. Individuals who were interested called the "Exerstrider office" during specified hours to request further information. Each individual was queried via a screening questionnaire and ultimately was chosen only if certain criteria were met (see

Appendix A). Finally, a 15 minute practice session was scheduled with each successfully screened subject.

Initially, 99 individuals were screened and recruited for the study.

Experimental Procedures

Practice Session

Approximately 1 week prior to pretesting, a 15 minute practice session was held. All subjects read and signed an informed consent form (see Appendix D), and also committed themselves to the study by presenting a \$40.00 check to be refunded upon satisfactory completion of the study. All subjects, regardless of which group they were assigned, were informed that after successfully completing the study they would receive a free pair of Exerstrider walking poles.

Next, the researcher gave directions to each subject regarding: 1) mounting and dismounting the treadmill safely (treadmill model # 24-72, Quinton Instruments - Seattle, WA); 2) proper body positioning and walking technique while on the treadmill; 3) the use of the heart rate strap, headgear, mouthpiece, and nose clip; and, 4) the Q-Plex gas analyzer was explained. Each subject walked on the treadmill for 5-10 minutes with headgear, mouthpiece, and noseclip in place at 3.00 mph and 0.0% grade to simulate pre- and posttesting conditions. When each subject felt comfortable on the treadmill, the speed was increased to a

brisk, but comfortable, "self-selected" speed typically between 3.25 and 4.00 mph. This speed was recorded and used later during that individual's pre- and posttest treadmill tests. Next, a modified Balke treadmill protocol (see Appendix B), as well as the Borg Rating of Perceived Exertion (RPE) Scale (see Appendix C), were explained. Finally, an appointment for the pretest was made and written instructions (see Appendix E) were given to each subject regarding their actual test.

Pretest/Posttest Session

Subjects were asked not to exercise 24 hours or eat 3-4 hours prior to their scheduled test time. The subjects were instructed to report to the Human Performance Laboratory in Mitchell Hall in comfortable exercise clothes and shoes. Before testing, the Q-Plex open circuit gas analyzer (model # Q-Plex 1, Quinton Instruments - Seattle, WA) was prepared and calibrated. Calibration consisted of: 1) entering ambient room conditions of temperature, barometric pressure, and relative humidity; 2) synchronizing calibration gases to the appropriate settings; and, 3) volume calibration via injecting a known volume of 3.002 liters into the pneumotach.

Upon arrival, each subject was weighed without shoes to the nearest quarter pound, and height was measured to the nearest quarter inch. A CIC Uniq Heart Watch System (model

8799, Computer Instruments Corporation - Hempstead, NY) strap was fitted transversely across the body and below the breast. The electrode portion of the unit, which makes contact with the skin, was moistened by spraying with distilled water. The subject warmed up at 3.0 mph and 0.0% grade for at least 5 minutes. During this warm up period the Q-Plex was programmed and the subject's weight and height were entered into the computer. After the warm up, the treadmill was stopped and the headgear (model # 2726, Hans Rudolph - Kansas City, MO) and valves (model # 2700, Hans Rudolph - Kansas City, MO) were fitted and secured onto the subject and a noseclip was affixed. Finally, one end of a corrugated breathing tube (1 3/8" diameter, 9' length, model # 9038, Hans Rudolph - Kansas City, MO) was attached to the two-way breathing valve, and the other end was affixed to the Q-Plex open circuit spirometer.

For the treadmill test, the subject first straddled the belt of the treadmill while the speed of the treadmill was increased to their predetermined personalized walking speed. Once the appropriate speed was attained, the subject was instructed to begin walking. A modified Balke treadmill protocol was used (see Appendix B). Heart rates were recorded every minute as were all gas parameters. A RPE value using the Borg 6-20 scale (see Appendix C) was recorded during the last 10 seconds of each 2 minute stage.

Criteria for maximal effort included an increase in workload with no further increase in oxygen consumption or heart rate, an R-value greater than 1.0, and lastly, the point when the subject was incapable of continuing due to volitional exhaustion. The ventilation ($\text{L}\cdot\text{min}^{-1}$), VO_2 ($\text{L}\cdot\text{min}^{-1}$, ($\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$), treadmill time (minutes), METS, R-value, heart rate ($\text{beats}\cdot\text{min}^{-1}$), and RPE were recorded at the end of each minute, each stage, and at maximal exercise.

Immediately postexercise, a cool down period was completed while walking at 2.75 mph and 0.0% grade for 5-10 minutes, or until the subject's heart rate "leveled off" at a constant rate (i.e., neither increasing or decreasing in rate).

Training

After all subjects were pretested, each subject was randomly assigned to one of three groups: Exerstriding (ES) $n = 29$, walking (W) $n = 30$, or control (C) $n = 27$ via coin toss. Subjects in the Exerstriding group trained by walking while using Exerstrider poles. Subjects in the walking group trained via walking only. Subjects in the control group did no training during the study, however, they were asked to maintain their current eating and activity patterns throughout the study's duration. Specific instructions were given during the first training week to the exercise groups regarding various key points: 1) stretching was to be done

before and after all exercise sessions; 2) heart rate monitoring was to be done by counting the radial or carotid pulse for 10 seconds prior to exercising, during the aerobic phase, and during the cool down period and recorded in personal logbooks (see Appendix F); 3) proper use of enhanced arm motions for those in the walking group, and proper coordination and use of poles for subjects in the Exerstriding group was explained.

Training consisted of exercising 4 days per week for 12 weeks, for a total of 48 sessions. Two of the 4 training sessions per week had to be supervised by a researcher at the quarter mile track located at the University of Wisconsin-La Crosse Memorial Field. The other two training sessions could be done at a place of the subject's own choosing, as long as it was done on level terrain.

Both the Exerstriding and walking groups trained for the same duration and at the same intensity (70-85% of their maximum heart rate, as obtained from the pretest) throughout the entire study. All exercising subjects started out at a low intensity/duration and increased gradually as the weeks progressed (see Appendix G). All subjects, including controls, were reminded to maintain their normal eating and activity patterns throughout the study. Subjects in both exercise groups logged exercise data such as: resting heart rate, exercise heart rate, cooldown heart rate, RPE, total

minutes of aerobic activity, total distance covered, and comments regarding their personal workout experiences (see Appendix F). These logbooks were collected each week and tabulated.

Statistical Treatment of Data

Descriptive characteristics, including means and standard deviations, were computed for all variables tested. To analyze changes from pre- to posttesting, change scores were calculated. Significant differences in change scores among Exerstriders, Walkers, and controls were analyzed using a one way analysis of variance (ANOVA). If there was a significant F ratio, a Tukey post-hoc test was used to detect pair-wise differences. The significance level for all ANOVA analyses was set at $p < .05$. Comparisons from pre- to posttest were analyzed using paired t-tests. Alpha was set at $p < .01$ for the t-test comparisons.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

The purpose of this chapter is to present the data collected before and after 12 weeks of Exerstrider and walking training. A total of 86 healthy, sedentary, nonsmoking, female volunteers between the ages of 20 to 50 years participated. Initially, 99 subjects were recruited. However, 13 dropped out of the study due to the following reasons: loss of interest (5), new job schedules (2), panic attacks during completion of posttest (2), sickness (2), and injury (2).

In addition to means and standard deviations of all variables, change scores between the pre- and posttests were calculated. Significant ($p < .05$) differences in change scores among Exerstriders, walkers, and controls were analyzed using a one way analysis of variance (ANOVA) with repeated measures. If there was a significant F ratio, a Tukey post-hoc test was used to detect pair-wise differences. Significant differences involving comparisons from pre- to posttest were analyzed using paired t-tests at the .01 level.

In this chapter, the data collected are presented and discussed in the following order: subjects' physical characteristics; training intensity; maximal VE; $VO_{2\max}$; maximal treadmill time; maximal R value; maximal heart rate; and, maximal RPE.

Subjects' Physical Characteristics

All data were obtained from subjects between the ages of 20 to 50 years who were screened prior to any testing. Descriptive data are displayed in Table 1.

Table 1. Physical characteristics of subject's (N = 86)

Variable	Exer (n = 29)	Walk (n = 30)	Control (n = 27)
Age (yr)	39.0* 6.1**	38.0 5.4	34.7 7.0
Weight (kg)	70.9 26.7	69.1 23.7	67.1 31.7
Height (cm)	164.6 2.2	165.1 2.3	163.8 2.5
Body Fat (%)	34.8 7.9	33.5 5.9	31.9 7.4

* = Mean ** = Standard Deviation

Training Intensity

The ACSM (1990) suggests that a training intensity of 60-90% of maximal heart rate, 50-85% of $VO_{2\max}$ or heart rate reserve be used to elicit a training response. These

criteria can be applied to almost all individuals because they are based relative to the individual's fitness level. In contrast, an absolute intensity of some specified amount may be too much or too little for different individuals.

Training at 76.4 and 77.2% of maximal heart rate occurred for Exerstriders and walkers, respectively, over the course of the 12 week study (see Table 2). An independent t-test found no significant ($p < .05$) difference between the two training intensities. Both exercise groups followed similar training parameters of frequency and duration as well during the 12 weeks. Training speeds averaged 3.7 and 3.9 mph, average distance covered during training was 2.4 and 2.6 miles, and average training time was 38.8 and 39.2 minutes for Exerstriders and walkers, respectively. Exerstriders trained at a speed 0.2 mph slower than the walkers which was found to be significantly ($p < .05$) different. In addition, the walkers exercised 0.2 miles further ($p < .05$) than the Exerstrider group during each allotted training session.

The training intensities for both groups were within the 70-85% of maximal heart rate suggested by the ACSM (1990) as an appropriate exercise intensity needed to elicit a training effect.

Table 2. Average training intensity, speed, time, distance, and RPE for Exerstriders (ES) and walkers (W).

Week #		Intensity (% MHR)	Speed (MPH)	Time (Min)	Distance (Mi)	RPE
1	ES	74.5	3.2	23.2	1.3	12.7
	W	73.3	3.0	24.1	1.3	12.8
2	ES	75.4	3.7	28.5	1.8	13.2
	W	76.6	3.7	28.5	1.8	13.1
3	ES	77.0	3.5	33.8	2.0	13.3
	W	77.3	3.9	33.0	2.1	13.2
4	ES	77.2	3.7	38.3	2.4	13.6
	W	77.1	3.8	38.7	2.4	13.3
5	ES	77.3	3.6	42.8	2.6	13.9
	W	77.5	3.8	42.7	2.7	13.5
6	ES	77.3	3.7	43.1	2.7	13.9
	W	77.7	4.1	43.5	3.0	13.6
7	ES	78.0	3.7	42.6	2.6	14.3
	W	78.8	4.0	43.8	2.9	14.1
8	ES	76.6	3.7	42.6	2.7	14.2
	W	77.6	4.0	43.9	2.9	13.5
9	ES	76.6	3.8	42.3	2.8	14.1
	W	77.9	4.1	43.7	3.0	13.8
10	ES	76.2	3.8	42.4	2.7	13.8
	W	78.2	4.1	42.8	3.0	13.6
11	ES	75.4	3.9	43.1	2.8	13.9
	W	77.4	4.2	43.2	3.1	13.6
12	ES	75.9	4.0	42.9	2.9	13.8
	W	76.8	4.2	42.9	3.1	13.6
Ave	ES	76.4	3.7*	38.8	2.4*	13.7*
	W	77.2	3.9*	39.2	2.6*	13.5*

* = Significant ($p < .05$) difference between ES and W.

Maximal Ventilation

The results of the present study found increases in V_E for the Exerstriders but not the walkers (see Table 3). The Exerstriders significantly ($p < .05$) increased their V_E by 3.8% (84.8 to 88.1 L·min⁻¹). Subjects in the walking group did not change. The increase in the Exerstrider V_E is less than the increases reported in other training studies (Kearney et al., 1976; Pollock et al., 1971).

Pollock et al. (1971) observed that walking for 20 weeks, 4 times per week had a marked influence on V_E in men. Their subjects showed an average increase of 15% (86.8 to 102.6 L·min⁻¹) during posttesting.

Similar results were reported for college women (Kearney et al., 1976). These women walked for 9 weeks, 3 times per week at 65% of HRR and increased their maximal V_E from 75.5 L·min⁻¹ to 85.5 L·min⁻¹ or an 11.6% increase.

Endurance exercise causes numerous adaptations in pulmonary ventilation when engaged in submaximal or maximal exercise. Even after 4 weeks of training, V_E is decreased at a submaximal level (McArdle et al., 1986). This adaptation decreases fatigue of respiratory muscles and allows more oxygen to be used by arm and leg muscles. In contrast, V_E typically increases during maximal effort after training. This increase is partially due to the increased

Table 3. Maximal pre- and posttest means, standard deviations, and per cent change for Exerstriders, walkers, and controls.

Group	Max V_E (L/min)	Max VO_2 (L/min)	Max VO_2 (ml/kg/min)	Max Time (min)	Max METS	Max R	Max HR (bpm)	Max RPE
<u>Exerstriders</u>								
Pre	84.75 ^a	2.33	33.68	11.23	9.62	1.078	184.03	19.31
	14.36 ^b	0.33	5.20	1.62	1.48	0.067	10.58	0.81
Post	88.06	2.51	36.50	13.67	10.43	1.102	185.28	19.86
	14.55	0.36	5.62	2.07	1.61	0.082	10.87	0.44
% ch	3.76*	7.17*	7.73*	17.85*	7.77*	2.178	0.67	2.77
<u>Walkers</u>								
Pre	92.31	2.45	36.48	11.82	10.42	1.076	185.11	19.39
	14.06	0.32	4.87	2.13	1.39	0.074	8.52	0.92
Post	92.04	2.65	39.46	14.91	11.28	1.070	185.57	19.89
	13.40	0.39	6.69	2.42	1.91	0.095	8.60	0.31
% ch	-0.29*	7.55*	7.55*	20.72	7.62*	-0.558	0.25	2.51
<u>Controls</u>								
Pre	90.90	2.45	37.53	12.67	10.72	1.063	186.70	19.56
	12.92	0.36	7.32	2.40	2.09	0.045	10.97	0.58
Post	85.38	2.42	36.90	13.87	10.54	1.071	186.81	19.96
	13.55	0.38	7.90	2.65	2.26	0.081	9.81	0.19
% ch	-6.07	-1.22	-1.68	8.65	-1.68	0.747	0.06	2.00

a = Mean b = Standard Deviation * = Significant difference ($p < .01$) between pre- and posttests

production of CO_2 at maximal effort which must be eliminated by increasing VE.

Lewis et al. (1983) found greater ventilatory volumes and greater tidal volumes in two-leg versus one-leg (or one-arm) exercise at any given work load. They attributed this increase in VE to a greater total metabolic demand. Oxygen usage and carbon dioxide production were higher when the larger muscle mass was used during testing, leading to higher ventilatory volumes.

The difference in ventilatory volume between Exerstriders and walkers may be attributed to the fact that the Exerstriders had adapted to exercise using both arms and legs. When testing occurred, poles were not used, thus, mainly the legs were used to perform the work. The legs alone possibly could not clear metabolic by-products of exercise as efficiently as the walkers. Thus, an increased ventilatory volume was called upon to remove excess CO_2 (lactate) generated by the legs. Although there was a significant increase, it was quite small.

$\text{VO}_{2\text{max}}$

$\text{VO}_{2\text{max}}$ values expressed relative to body weight, in absolute terms, or as METS, were significantly ($p < .05$) higher in Exerstriders and walkers than controls after 12 weeks of training. Relative $\text{VO}_{2\text{max}}$ increases of 7.7 and 7.6% were seen in the Exerstriders and walkers,

respectively. Absolute increases ranged from an average of 7.2 and 7.6% for the Exerstriding and walking groups, respectively. There were no significant ($p < .05$) differences in these values for the controls. Furthermore, there were no significant ($p < .05$) differences in improvement between training groups.

The findings from the Exerstrider group agree with similar studies (Simard & Roy, 1979; Toner et al., 1983) that found increased VO_{2max} levels associated with upper body training. In addition, the increases for the walking group were supported by similar studies (Flint et al., 1974; Foster et al., 1989; Kilbom & Astrand, 1971) which showed increased aerobic capacity after a walking training program. The changes in VO_{2max} were smaller than the increases reported for younger women, but similar to those for older women.

Kilbom and Astrand (1971) discovered that in young females, age 21 - 28, VO_{2max} increased by 10.3% after only 7 weeks of training. An older group, age 53 - 61, displayed an increase of 6.3% after training 7 weeks.

As Foster et al. (1989) demonstrated, women between the ages of 67 - 89 years who exercised at either moderate (60% of HRR) or low (40% of HRR) intensities significantly increased their VO_{2max} after a 10 week training program. An

increase in relative VO_2max of 15.4% occurred with moderate intensity.

Greater increases were reported for VO_2max after 16 weeks of training, from 3.15 to 3.68 $\text{L}\cdot\text{min}^{-1}$, or 14.4% (Ekblom, Astrand, Saltin, Stenberg, & Wallstrom, 1968). They found the increase was due to an enhanced arteriovenous oxygen difference. Cardiac output increased from 22.4 to 24.2 $\text{L}\cdot\text{min}^{-1}$, and was thought to be the causative factor in the enhancement of VO_2max .

In an investigation by Oscai et al. (1968), 47 training sessions were performed over a 16 week time period. An average VO_2max increase of 18% or 560 ml was found. Oscai et al. (1968) partially attributed this increase to the fact that the subjects' total blood volume increased by 338 ml or 6%. Total blood volume did not display a significant change in the control subjects who remained sedentary.

Thus, improvement in the experimental group within this author's study may be due to the longer training periods and accompanying cardiovascular adaptations in cardiac output, increased total blood volume, and enhanced arteriovenous oxygen difference.

Although both training groups increased their VO_2max , there was no significant ($p < .01$) differences in the amount of increase between the Exerstriders and walkers. One would expect the Exerstriders to elicit an increase beyond that of

the walkers due to increased upper body cardiovascular development. However, during treadmill testing, poles were not used by the Exerstriders because of the narrow width of the treadmill. This may have made a difference due to the specificity of training principle of McArdle et al. (p. 349, 1986) that states "specific exercise elicits specific adaptations, creating specific training effects". It should be stressed that both experimental groups exercised at the same intensity, while Exerstriders traveled significantly ($p < .05$) slower and covered less distance than the walkers.

In a study done by Magel, McArdle, Toner, and Delio (1978), VO_{2max} was measured in each subject via treadmill running and arm ergometry. Subjects then trained 10 weeks with arm ergometers. Posttesting showed that the treadmill VO_{2max} did not change with arm ergometer training, whereas the arm ergometry VO_{2max} did. It was suggested that specificity of training played a large role in their VO_{2max} performance.

When analyzing VO_{2max} in specifically trained athletes, specificity of training is a factor that must be addressed. Therefore, the type of test used must be considered and should optimally involve use of the muscle fibers that were specifically trained. In the present study, all subjects (Exerstriders, walkers, and controls) were tested using a walking treadmill protocol regardless of training mode.

This was done because a narrow treadmill belt would not allow the Exerstriding subjects to engage in correct form (i.e., using their poles) during the test itself.

R Value

Maximal R value did not show a significant ($p < .05$) difference between the pre- and posttest for any group. Also, no significant ($p < .01$) differences were seen when comparing changes in the R value in Exerstriders compared to walkers.

Babyak et al. (1991) found a significantly higher R value for Exerstriders compared to walkers during 2 trials of submaximal treadmill walking (1 trial with, the other without Exerstrider poles). They attributed this finding to the increased muscle mass utilized by the Exerstriding subjects, as well as the significantly ($p < .05$) increased VO_2 cost of the Exerstriders compared to the walkers.

In the present study, since maximal efforts were given during both pre- and posttesting, there were no corresponding differences in R value.

Maximal Heart Rate

Maximal heart rate (bpm) was not altered ($p < .05$) as a result of the 12 week training program for any group. In addition, there was no significant ($p < .01$) changes between Exerstriders and walkers.

The lack of a significant change in maximal heart rate is supported by numerous studies (Ekblom et al., 1968; Kearney, et al., 1976; Mostardi, et al., 1981; Pollock, et al., 1971). Indeed, Ekblom et al. (1968) indicated that stroke volume was found to have significantly ($p < .05$) increased from 112 to 127 ml (an 11% increase). With training, the heart becomes more efficient at ejecting blood out with each beat. Therefore, an increase in heart rate is not required (in a trained heart compared to an untrained heart). They concluded that for cardiac output to have increased, without a rise in heart rate, stroke volume increased. According to McArdle et al. (1986, p.261), when the heart is under maximal sympathetic stimulation, the ventricles' ability to pump blood is doubled.

Durstine and Pate (1988, pp 49-50) stated, "Maximal heart rate is relatively constant across various conditions". The results of the present study agree with this statement since the maximal heart rates were not significantly altered.

Maximal RPE

Maximal RPE was not significantly changed ($p < .05$) for any group as a result of the 12 week training program. Maximal values of 19.86, 19.89, and 19.96 were seen for Exerstriders, walkers, and controls respectively, during

posttesting. These values were 2.8, 2.5, and 2.0% higher than pretesting, but were not significant.

Borg (1982) cited RPE as the best way to substantiate physical strain or intensity of an activity. He felt that the range of 6 to 20 generally represents heart rates ranging from 60 to 200. However, a literal/exact relationship between heart rate and RPE cannot be assumed because an exertion level is linked to many variables such as age, environment, mode of exercise, and anxiety level.

In a study of simulated cross country skiing, various combinations of combined arm and leg work, leg work only, and arm work only were studied (Millerhagen et al., 1983). Millerhagen et al. found that RPE was significantly ($p < .05$) less in the combined arm and leg trial during every stage of testing including maximal intensity. It was thought that the upper body musculature may have delayed some of the fatigue within the legs as compared to the leg only trial.

Mostardi et al. (1981), in research focusing on cycle ergometry training using arms and legs versus legs alone, found differences in perceived exertion between the two modes of exercise. During maximal trials where both arms and legs were used, each subject noticed a definite ease regarding effort as compared to the same workload using legs alone. In 9 of the 11 subjects, VO_{2max} was identical with

both modes of exercise, however, RPE during arm and leg exercise was perceived as much easier.

According to Franklin (1989, p. S146), an increased amount of muscle mass is used in combined arm-leg ergometry compared to arm alone or leg alone ergometry. It was stated that "perception of effort (RPE) is related more to the metabolic rate per area of muscle than to the absolute oxygen uptake per se".

In the present study, RPE was not changed in any of the groups. Since poles were not used during the maximal treadmill tests, this may have had an effect on the unchanged maximal RPE values of the Exerstrider group.

Maximal Treadmill Time

The means, standard deviations, and percent change for maximal treadmill time (min) are presented in Table 3 for Exerstriders, walkers, and controls. Although all groups demonstrated an increase in time (min) to exhaustion, only the Exerstriders' and walkers' times were significantly ($p < .01$) increased after 12 weeks. There was no significant ($p < .01$) differences in treadmill time when comparing training groups.

The Exerstriders improved their treadmill time by 17.9% (2.44 min), the walkers 20.7% (3.09 min), and the controls increased by 8.7% (1.20 min). It was hypothesized that the Exerstriders "would have" increased their treadmill time

more than the walkers due to their training of the upper body. But the difference in treadmill time was not significant ($p < .01$) between the Exerstriding and walking groups. Again, it should be emphasized that during the maximal treadmill test, poles were not able to be used by the Exerstrider group. This may have made a difference due to the specificity of training principle discussed previously.

When recognizing the increased $VO_2\text{max}$ values of the experimental groups, it would seem appropriate that there would be accompanying increases in treadmill time between pre- and posttesting. Indeed, this did occur. The increase in $VO_2\text{max}$ was not as great as the accompanying increase in treadmill time. This agrees with one of the basic definitions of $VO_2\text{max}$ (i.e., an increase in workload without an increase in oxygen consumption). Apparently the increase in treadmill time could not be attributed to a learning effect since the control group's treadmill time was not significantly increased.

Summary

Exerstriding is an aerobic activity which actively involves contraction of the upper as well as lower body muscles to propel the exerciser forward. During a walking workout, mainly the lower body muscle mass is used for moving the body forward while the arms either hang or swing

to provide balance. Inherently, the legs are active in both Exerstriding or walking. Theoretically, an activity which uses the lower body while simultaneously utilizing the upper body would offer a greater workout. Oxygen consumption would be increased above walking alone due to the increased amount of active muscle mass. Exerstriding, which involves the upper body muscles, would, in theory, be expected to elicit a higher VO_{2max} as compared to walking.

In this study, the Exerstrider group did not elicit a greater improvement in VO_{2max} than the walking group when all groups were tested on a treadmill using a walking protocol. This may have been due to many factors, possibly the biggest reason being specificity of training.

A final emphasis must be made regarding training intensity, distance, and speed. Both training groups exercised throughout the 12 week study at the same training intensity. However, the Exerstrider group trained at a slower speed than the walking group, and walked a shorter distance than the walkers during each training session.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to compare the changes in cardiorespiratory responses to a maximal treadmill test in women who either Exerstrided or walked for 12 weeks. Subjects in the study were 86 sedentary/untrained females who ranged in age from 20 to 50 years (\bar{x} = 37 years).

Each subject underwent a pre and post maximal treadmill test during which maximal ventilation ($L \cdot \text{min}^{-1}$), VO_2 ($L \cdot \text{min}^{-1}$, $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, and METS), treadmill time (min), R value, heart rate (bpm), and RPE were determined. The 12 weeks of training involved exercising 4 times per week, at an average of 39 minutes a session. Training intensity was monitored by taking frequent exercise pulse checks. Exerstriders and walkers maintained an average intensity of 76.0 and 77.0% of maximal heart rate, respectively, while training. In addition, average speed and duration of training during each exercise session was 3.7 and 3.9 mph, and 2.4 and 2.6 miles, respectively for Exerstriders and walkers.

Significant ($p < .05$) differences in training intensity, speed, and duration were calculated via independent t-tests. The walking group walked significantly

($p < .05$) faster in speed (mph), and traversed a longer distance (mi) during each exercise session compared to the Exerstriders. Thus, the Exerstriders achieved the same training intensity at a slower speed and did not have to go as far.

Conclusions

According to the statistical analysis of data of this study, the following conclusions were made:

1. There were no significant differences in the changes in maximal heart rate, maximal R value, and maximal RPE, between the Exerstrider, walker, and control groups as a result of training 12 weeks.
2. The Exerstrider group displayed a significant ($p < .05$) increase in maximal ventilation between pre- and posttests, but the walkers and controls did not.
3. Both experimental groups displayed significant ($p < .05$) increases in maximal VO_2 ($\text{L}\cdot\text{min}^{-1}$, $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, METS), and treadmill time between pre- and posttests, while the controls did not. However, there were no differences in the changes between the walkers and the Exerstriders.
4. There was no significant ($p < .05$) differences in maximal heart rate, R value, and RPE for either the Exerstrider, walker or control group between pre- and posttests.
5. The Exerstrider group was able to train at a significantly ($p < .05$) slower speed than the walking

group yet maintain the same percent of maximal heart rate during each session.

6. The value of Exerstriding and/or walking as an effective aerobic exercise modality for improving cardiorespiratory fitness was established in this study.

Recommendations

Future Studies

Due to the fact that the Exerstrider subjects did not display maximal values significantly different than the walkers in VO_2 , heart rate, R value, RPE, and treadmill time, research should be done to further pursue the aerobic gains that can be made with the use of Exerstrider poles. Another set of recommendations based upon the results of this study are as follows:

1. Due to the fact that the Exerstrider subjects trained with poles, but were tested without them, a study should be conducted where poles are used during VO_{2max} pre- and posttesting.
2. A similar 12 week training study should be done in which Exerstriders perform two VO_{2max} posttests, one with and one without poles.
3. Other combined upper/lower body activities such as cross country skiing and use of a Nordic Trak ski simulator should be compared with Exerstriding in a training study.

4. Use of highly trained athletes should be conducted to determine whether Exerstriding and walking elicit similar cardiorespiratory increases in this population of subjects.

Practical Application

The individuals who used Exerstriders in this study maintained the same intensity level (training heart rate) as the walking group, yet traveled significantly slower. There are various practical applications involving exercise that can be applied from this fact. Exercise specialists/leaders have yet another mode of exercise to prescribe to a more diverse and varied population. For example, Exerstriding could be prescribed to the individual who, because of a slower walking speed, cannot attain their suggested target heart rate. These individuals may include, for example, the elderly, cardiac or physical rehabilitation patients, people with various chronic mechanical limitations, or those individuals who are by nature slower in walking speed.

For those individuals who maintain a regular fitness training regimen, Exerstriding offers itself as an inviting low impact alternative, without all the physical pounding that occurs with other common aerobic activities such as jogging or running. Use of Exerstriders could easily be incorporated into any cross-training program, or as the dominant exercise mode for people who need to monitor

themselves, and/or curtail their exercise habits (in relation to overuse injuries).

REFERENCES

- American College of Sports Medicine. (1990). Position statement on the recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness in healthy adults. Medicine and Science in Sports and Exercise, 22(2), 265-274.
- Auble, T. E., & Schwartz, L. (1991). Physiological effects of exercising with handweights. Sports Medicine, 11(4), 244-256.
- Babyak, D., Van Heest, J., & Rodgers, C. (1991). The effects of Exerstrider use during steady-state treadmill walking on cardiorespiratory parameters. Medicine and Science in Sports and Exercise, 23(4), (Suppl. 861), 144.
- Bergh, U. (1987). The influence of body mass in cross-country skiing. Medicine and Science in Sports and Exercise, 19(4), 324-331.
- Bergh, U., Kanstrup, I., & Ekblom, B. (1976). Maximal oxygen uptake during exercise with various combinations of arm and leg work. Journal of Applied Physiology, 41, 191-196.
- Black, A., Ribeiro, J., & Bochesse, M. (1984). Effects of previous exercise on the ventilatory determination of the aerobic threshold. European Journal of Applied Physiology, 52, 315-319.
- Borg, G. (1982). Psychophysical bases of perceived exertion. Medicine and Science in Sports and Exercise, 14(5), 377-381.
- Brynteson, P., & Sinning, W. (1973). The effects of training frequencies on the retention of cardiovascular fitness. Medicine and Science in Sports, 5(1), 29-33.
- Clausen, J. P., Klausen, K., Rasmussen, B., & Trap-Jensen, J. (1973). Central and peripheral circulation changes after training of the arms or legs. American Journal of Physiology, 225, 675-682.

- Durstine, L., & Pate, R. (1988). Cardiorespiratory responses to acute exercise. In S. N. Blair, P. Painter, R. Pate, L. K. Smith, & C. B. Taylor (Eds.), Resource manual for exercise testing and prescription. (pp. 49-50). Philadelphia, PA: Lea & Febiger.
- Ebbeling, C., Ward, A., Puleo, E., Widrick, J., & Rippe, J. (1991). Development of a single-stage submaximal treadmill walking test. Medicine and Science in Sports and Exercise, 23(8), 966-973.
- Edwards, M. A. (1974). The effects of training at predetermined heart rate levels for sedentary college women. Medicine and Science in Sports and Exercise, 6(1), 14-19.
- Ekblom, B., Astrand, P., Saltin, B., Stenberg, J., & Wallstrom, B. (1968). Effect of training circulatory response to exercise. Journal of Applied Physiology, 24(4), 518-528.
- Flint, M. M., Drinkwater, B. L., & Horvath, S. M. (1974). Effects of training on women's response to submaximal exercise. Medicine and Science in Sports, 6(2), 89-94.
- Foster, V., Hume, G., Byrnes, W., Dickinson, A., & Chatfield, S. (1989). Endurance training for elderly women: Moderate versus low intensity. Journal of Gerontology, 44(6), M184-M188.
- Franklin, B. A. (1989). Aerobic exercise training programs for the upper body. Medicine and Science in Sports and Exercise, 21, S141-S148.
- Franklin, B., Kaimal, K., Moir, T., & Hellerstein, H. (1981). Characteristics of national-class race walkers. Physician and Sports Medicine, 9, 101-108.
- Graves, J., Pollock, M., Montain, S., Jackson, A., & O'Keefe, J. (1987). The effect of hand-held weights on the physiological responses to walking exercise. Medicine and Science in Sports and Exercise, 19, 260-275.
- Hagberg, J. M., & Coyle, E. F. (1984). Physiologic comparison of competitive racewalking and running. International Journal of Sports Medicine, 5, 74-77.

- Hanson, J. S. (1973). Maximal exercise performance in members of the U.S. Nordic Ski Team. Journal of Applied Physiology, 35(5), 592-595.
- Hanson, P. (1988). Clinical exercise testing. In S. N. Blair, P. Painter, R. R. Pate, L. K. Smith, and C. B. Taylor (Eds.), Resource manual for guidelines for exercise testing and prescription. (p. 210). Philadelphia, PA: Lea & Febiger.
- Hickson, R., & Rosenkoetter, M. (1981). Reduced training frequencies and maintenance of increased aerobic power. Medicine and Science in Sports and Exercise, 13(1), 13-16.
- Holly, R. (1988). Measurement of the maximal rate of oxygen uptake. In S. N. Blair, P. Painter, R. R. Pate, L. K. Smith, and C. B. Taylor (Eds.), Resource manual for guidelines for exercise testing and prescription. (p. 171). Philadelphia, PA: Lea & Febiger.
- Hovell, M., Sallis, J., Hofstetter, C., Spry, V., Faucher, P., & Caspersen, C. (1989). Identifying correlates of walking for exercise: An epidemiological prerequisite for physical activity promotion. Preventive Medicine, 18, 856-866.
- Kearney, J., Stull, G., Ewing, J., & Strein, J. (1976). Cardiorespiratory responses of sedentary college women as a function of training intensity. Journal of Applied Physiology, 41(6), 822-825.
- Kilbom, A., & Astrand, I. (1971). Physical training with submaximal intensities in women: Effect on cardiac output. Scandinavian Journal of Clinical Laboratory Investigation, 28, 163-175.
- Lewis, S., Taylor, F., Graham, R., Pettinger, W., Schutte, J., & Blomquist, G. (1983). Cardiovascular responses to exercise as functions of absolute and relative work load. Journal of Applied Physiology, 54(5), 1314-1323.
- Luria, M. H., & Koepke, K. R. (1975). The physical conditioning effects of walking. Journal of Sports Medicine, 15, 272-275.

- MacDougall, J. D., Hughson, R., Sutton, J. R., & Moroz, J. R. (1979). The energy cost of cross-country skiing among elite competitors. Medicine and Science in Sports, 11(3), 270-273.
- Magel, J. R., McArdle, W. D., Toner, M., & Delio, D. J. (1978). Metabolic and cardiovascular adjustment to arm training. Journal of Applied Physiology: Respiratory, Environmental, Exercise Physiology, 45, 75-79.
- Martin, W., Kohrt, W., Malley, M., Korte, E., & Stoltz, S. (1990). Exercise training enhances leg vasodilatory capacity of 65-year-old men and women. Journal of Applied Physiology, 69(5), 1804-1809.
- Martin, D., Notelovitz, M., Fields, C., & O'Kroy, J. (1989). Predicting maximal oxygen uptake from treadmill testing in trained and untrained women. American Journal of Obstetrics and Gynecology, 161, 1127-1132.
- McArdle, W., Magel, J., Delio, D., Toner, M., & Chase, J. (1978). Specificity of run training on VO_{2max} and heart rate changes during running and swimming. Medicine and Science in Sports, 10(1), 16-20.
- McArdle, W. D., Katch, F. I., & Katch, V. L. (1986). Exercise physiology, energy, nutrition, and human performance (2nd ed.). Philadelphia, PA: Lea & Febiger.
- Millerhagen, J. R., Kelly, J. M., & Murphy, R. F. (1983). A study of combined arm and leg exercise with application to Nordic skiing. Canadian Journal of Applied Sport Sciences, 8(2), 92-97.
- Mostardi, R. A., Gandee, R. N., & Norris, W. A. (1981). Exercise training using arms and legs versus legs alone. Archives of Physical Medicine and Rehabilitation, 62, 332-336.
- Nagle, F., Richie, J., & Giese, M. (1984). VO_{2max} responses in separate and combined arm and leg air-braked ergometer exercise. Medicine and Science in Sports and Exercise, 16, 563-566.
- Ng, A. V., Demment, R. B., Jassett, D. R., Bussan, M. J., Clark, R. R., Kuta, J. M., & Schauer, J. E. (1988). Characteristics and performance of male citizen cross-country ski racers. International Journal of Sports Medicine, 9, 205-209.

- Oscai, L., Williams, B., & Hertig, B. (1968). Effect of exercise on blood volume. Journal of Applied Physiology, 24(5), 622-624.
- Pate, R., Blair, S., Durstine, J., Eddy, D., Hanson, P., Painter, P., Smith, L., & Wolfe, L. (Eds.). (1991). Guidelines for Exercise Testing and Prescription. Par-Q Validation Report, 37.
- Pate, R., Hughes, R., Chandler, J., & Ratliffe, J. (1978). Effects of arm training on retention of training effects derived from leg training. Medicine and Science in Sports, 10(2), 71-74.
- Pollock, M., Miller, H., Janeway, R., Linnerud, A., Robertson, B., & Valentino, R. (1971). Effects of walking on body composition and cardiovascular function of middle-aged men. Journal of Applied Physiology, 30(1), 126-130.
- Porcari, J., Kline, G., Hintermeister, R., Freedson, P., Ward, A., Gurry, M., Ross, J., McCarron, R., & Rippe, J. (1986). Is fast walking an adequate aerobic training stimulus? Medicine and Science in Sports and Exercise, 18(2), (Suppl. 81).
- Porcari, J., McCarron, R., Kline, G., Freedson, P., Ward, A., Ross, J., & Rippe, J. (1987). Is fast walking an adequate aerobic training stimulus for 30-to-69-year-old men and women? Physician and Sportsmedicine, 15, 119-129.
- Raab, D. M., Smith, R. T., Smith, E. L., & Gilligan, C. (1985). Energy cost of wearing weighted bands while walking and jogging. Medicine and Science in Sports and Exercise, 17, 268. (From Annual Meeting Abstracts, American College of Sports Medicine, 1985, 17, Abstract No. 15).
- Rogers, C. C. (1986). Upper body exercise: Jarring instead of jogging. The Physician and Sportsmedicine, 14(5), 181-186.
- Schultz, P. (1980). Walking for fitness: Slow but sure. The Physician and Sportsmedicine, 8(9), 24-27.

- Sedlock, D., Fissinger, J., & Melby, C. (1989). Effect of exercise intensity and duration on postexercise energy expenditure. Medicine and Science in Sports and Exercise, 21(6), 662-666.
- Sharkey, B. (1970). Intensity and duration of training and the development of cardiorespiratory endurance. Medicine and Science in Sports, 2(4), 197-202.
- Simard, C. P., & Roy, J. R. (1979). Biological changes after one season of cross country skiing adapted to old people. Medicine and Science in Sports and Exercise, 11, 101-105.
- Soule, R. G., & Goldman, R. F. (1969). Energy cost of loads carried on head, hands, or feet. Journal of Applied Physiology, 27, 687-690.
- Stamford, B. (1984). Exercising with hand and ankle weights. The Physician and Sportsmedicine, 12(12), 139.
- Suominen, H., Lic, P., Heikkinen, E., & Parkatti, T. (1977). Effect of eight weeks' physical training on muscle and connective tissue of the vastus lateralis in 69-year-old men and women. Journal of Gerontology, 32(1), 33-37.
- Taylor, H. L., Buskirk, E., & Henschel, A. (1955). Maximal oxygen uptake as an objective measure of cardiorespiratory performance. Journal of Applied Physiology, 8, 73-80.
- Toner, M. N., Sawka, M. N., Levine, L., & Pandolf, K. B. (1983). Cardiorespiratory responses to exercise distributed between the upper and lower body. Journal of Applied Physiology: Respiratory, Environmental, and Exercise Physiology, 54, 1403-1407.
- Ward, A., Ebbeling, C. B., Porcari, J. P., Puleo, E. M., Morris, D. M., & Rippe, J. M. (1990). Increased aerobic capacity with low intensity walking program. Medicine and Science in Sports and Exercise, 22, S65. (From Annual Meeting Abstracts, American College of Sports Medicine, 1990, 22(2), Abstract No. 389).
- Wasserman, K., & Whipp, B. (1975). Exercise physiology in health and disease. American Review of Respiratory Disease, 112, 219-224.

Weltman, A., Weltman, J., Rutt, R., Seip, R., Levine, S., Snead, D., Kaiser, D., & Rogol, A. (1989). Percentages of maximal heart rate, heart rate reserve, and VO_2 peak for determining endurance training intensity in sedentary women. International Journal of Sports Medicine, 10(3), 212-216.

APPENDIX A
PHONE CONVERSATION SEQUENCE

PHONE CONVERSATION SEQUENCE

- 1) Hello! Exerstrider office, this is _____, may I help you?
- 2) Purpose: The purpose of our study is to determine if there are any additional training responses obtained when using Exerstrider walking poles as compared to normal walking.
- 3) Groups: We are going to have 3 groups you may randomly be assigned to: a walking group, a control group, or an Exerstrider group (using Exerstrider walking poles). Whatever group you're in, you are guaranteed a free (\$50.00 pair) of Exerstrider walking poles if you successfully complete the study. Control group members, in addition, get a free 3 month membership in our Noon Walk Program, or Adult Fitness Program.
- 4) Scheduling: As far as scheduling is concerned, a 15 minute practice session needs to be made either July 2nd, 3rd, 5th, or 6th. Pre testing (2 hours total) will be July 6th - 14th. Post testing (2 hours total) will be October 5th - 13th. Your attendance at these sessions is necessary.
- 5) Testing: A battery of tests will be given to you.
 - A) You will fill out a "well-being" paper and pencil inventory.
 - B) Your percent body fat will be obtained via skinfold measurement and then by underwater weighing, which is the most accurate method.
 - C) Your shoulder strength and endurance will be assessed.
 - D) Cardiovascular endurance will be assessed on a treadmill while you are walking uphill.
- 6) Training: If assigned to an exercise group, you will train for 12 weeks. Four exercise sessions per week will be done, at least 2 exercise sessions will be supervised by a researcher at UW-L, preferably on our quarter-mile outdoor track, or eighth-mile indoor track during inclement weather.
- 7) Training Times: Monday-Friday 6-8 AM, or 4-6:30 PM, or Saturday 8-10 AM. At least 2 of your training sessions need to be done at these times with us.
- 8) Cost: A \$40.00 deposit (check) is needed, which will be returned to you after you successfully complete the study, which will equal a total of 48 training sessions. This cost is only for incentive purposes. We do not want your money, we want you as a participant!
- 9) Now we need to make a practice appointment which will last about a 1/2 hour. (Fill in her name in a time slot on the master practice schedule).
- 10) Please report to room 221 of Mitchell Hall (UW-L).
- 11) Any questions? We'll see you at: date?, time?

12) Questionnaire for Exerstrider Study

- A) Get her name, phone number, and age.
- B) Ask questions 1-8. One "no" = exclusion from the study.
- C) Ask questions 1-6. One "yes" = exclusion from the study.
- D) Ask questions 1-5. Only one "yes" is allowed, no more!

Questionnaire for Exerstrider Study

Name: _____ Phone#: _____ Age: _____ Birthday: _____
 Address: _____

General Questions

Please answer Yes/No to the following questions.

- Yes No 1. Are you comfortable in/under water (hydrostatic weighing)?
- Yes No 2. Are you available for Practice/Pre/PostTesting July 6-14 and October 5-13?
- Yes No 3. Are you willing to train 4 days per week (at least 2 supervised) for 12 weeks during the following times? 6-8 AM M-F, 4-6:30 PM M-F, 8-10 AM Sat.?
- Yes No 4. Will you agree to participate regardless of what group (walking, Exerstrider, or control) you are randomly assigned to?
- Yes No 5. Do you consider yourself to be inactive or untrained? If not please explain.
- Yes No 6. Will you agree not to engage in any additional exercise beyond your current level?
- Yes No 7. Will you agree not to change your normal diet or go on a restricted calorie diet?
- Yes No 8. Are you willing to make a \$40.00 deposit to be refunded after final testing?

Physical Activity Readiness Questionnaire (PAR-Q)*

Please answer Yes/No to the following questions.

- Yes No 1. Has your doctor ever said you have heart trouble?
 - Yes No 2. Do you frequently suffer from pains in your chest?
 - Yes No 3. Do you often feel faint or have spells of severe dizziness?
 - Yes No 4. Has your doctor ever said that your blood pressure was too high?
 - Yes No 5. Has a doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise?
 - Yes No 6. Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to?
- *(Pate et al., 1991).

Major Coronary Risk Factors

Please answer Yes/No to the following questions.

- Yes No 1. Diagnosed hypertension, or SBP > 160, or DBP > 90 mmHg on at least 2 separate occasions, or on antihypertensive medication?
- Yes No 2. Serum cholesterol > 6.20 mmol/L (> 240 mg/dl)?
- Yes No 3. Cigarette smoking?
- Yes No 4. Diabetes mellitus?
- Yes No 5. Family history of coronary or other atherosclerotic disease in parents or siblings prior to age 55?

Completed by: Jim / Laurie / Anna-Marie / Ariel
(circle one)

Date: _____

Time: _____ AM / PM

APPENDIX B
TREADMILL PROTOCOL

Treadmill Protocol
Exerstrider / Walking Study
Modified Balke

<u>(mph)</u>	<u>Time (min)</u>	<u>Grade (%)</u>	<u>Speed</u>
1	0 - 2	0.0 %	* Self Selected
2	2 - 4	2.5 %	"
3	4 - 6	5.0 %	"
4	6 - 8	7.5 %	"
5	8 - 10	10.0 %	"
6	10 - 12	12.5 %	"
7	12 - 14	15.0 %	"
8	14 - 16	17.5 %	"
9	16 - 18	20.0 %	"
10	18 - 20	22.5 %	"
11	20 - 22	25.0 %	"
12	22 - 24	27.5 %	"

* Walking speeds chosen included: 3.00, 3.25, 3.75, and 4.00 mph.

APPENDIX C

RATING OF PERCEIVED EXERTION SCALE

Rating of Perceived Exertion (Borg scale)

During your treadmill test, we want you to pay close attention to how hard you feel the work rate is. This feeling should be your total amount of exertion and fatigue, combining all sensations and feelings of physical stress, effort, and fatigue. Don't concern yourself with any one factor such as leg pain, shortness of breath, or exercise intensity, but try to concentrate on your total inner feeling of exhaustion. Don't underestimate or overestimate, just be as accurate as you can. Thank you.

(Borg Scale) Rating of Perceived Exertion

6	
7	very, very light
8	
9	very light
10	
11	fairly light
12	
13	somewhat hard
14	
15	hard
16	
17	very hard
18	
19	very, very hard
20	

APPENDIX D
INFORMED CONSENT

INFORMED CONSENT
EXERSTRIDER-WALKING STUDY

I, _____, volunteer to be a subject in a research study to determine what, if any, difference in VO_{2max} , body composition and strength occur as a result of participating in a walking training program and a walking program using Exerstriders. I understand participation in this project requires that I have my percent body fat determined hydrostatically, complete a maximal treadmill walking test to exhaustion, have my upper body strength and endurance determined, and complete a personal profile inventory. In addition, I will be randomly assigned to one of three groups (i.e., control, regular walking, or Exerstrider walking) thus I may or may not be required to participate in a 12-week exercise program.

The 12-week training program will consist of walking between 20 and 60 minutes, 4 days per week for a total of 48 sessions. These sessions will be supervised and individually designed to elicit between 60 and 80% of my maximal capacity as determined by heart rates during the treadmill walk.

The hydrostatic weighing involves having my percent body fat determined through the hydrostatic (underwater) weighing technique and various anthropometric measures. The hydrostatic weighing procedure involves having my residual lung volume determined while breathing into a spirometer. I also will be required to have my body weight determined while I am completely submerged underwater. When working in a water environment, there is a risk of infection, accident, and possible drowning. However, there has never been a serious accident or report of infection as a result of the hydrostatic weighing procedures in the Human Performance Laboratory (HPL).

The treadmill test will consist of walking on the treadmill at a speed of my own choosing. Once this speed has been selected, the grade of the treadmill will be increased 2.5% every 2 minutes until I reach volitional exhaustion. During this test, my heart rate will be monitored continuously with a heart monitor strapped to my chest. Also, I will breathe room air through a mouthpiece so that my exhaled air can be collected and analyzed. Although this test will require maximal effort, I understand that I can stop the test anytime I wish. As with any exercise, there exists the possibility of adverse changes occurring (i.e., dizziness, difficulty in breathing, etc.) during this test. In addition, I will probably feel tired at the end of the test. If any abnormal observations are noted at any time, the test will be immediately terminated.

Upper body strength and endurance (arm and shoulder) will be determined using a modified isokinetic swim bench. This test requires that I perform a series of contractions with both arms to exhaustion. This test will leave my arms extremely tired for a short time (i.e., probably 15-20 minutes). In addition, some delayed muscle soreness may occur during the next day or two. This soreness will diminish with no long term effects.

The personal profile inventory will be a "paper and pencil" test to determine what, if any, effect the training program has on my attitude and how I perceive my body.

All practice and testing sessions will be scheduled at my convenience. The tests and practice sessions will be supervised and conducted by N. K. Butts, PH.D., and John Porcari, Ph.D., with assistance from skilled graduate students (Jim Larkin, Laurie Stoughton, Anna-Marie Postmus, and Ariel Karawan).

Once I have completed the requirements for my group (training and/or all tests), I will receive a pair of Exerstrider poles and a summary of my results. Those individuals randomly assigned to the control group will also be given the opportunity to complete a 12 week training program through the La Crosse Exercise and Health Program as well as a free pair of Exerstrider poles.

I consider myself to be in good health and to my knowledge I am not infected with a contagious disease or have any limiting physical condition or disability, especially with respect to my heart, that would preclude my participation in the tests as described above. I have truthfully answered and "passed" the attached Physical Activity Readiness Questionnaire which indicates that physical activity should not pose a problem or potential hazard for me.

I have read the foregoing and I understand what is expected from me. Any questions which may have occurred to me have been answered to my complete satisfaction. I, therefore, voluntarily consent to be a subject in this study. Furthermore, I know I may withdraw at any time but may be required to forfeit part or all of my \$40.00 deposit.

Signed: _____ Date: _____

Witness: _____ Date: _____

Please be aware that numerous technicians, equipment, etc., are required to administer the tests outlined above. In most laboratories, the cost of this test battery would exceed \$100.00. In order to demonstrate your commitment to the above study, a fully refundable \$40.00 deposit (make check out to L.E.H.P.) will be required prior to, or at your practice session. This deposit will be totally refunded upon successful completion of the post test - assuming that you have also successfully completed 48 training sessions if you are in a training group. In addition, all participants will receive, at no cost, a set of Exerstrider poles at this time. No part of this deposit will be refunded if you do not successfully complete all aspects of this study as outlined above.

Note: Your deposit will be refunded if any medical situation results in your inability to physically complete the study.

Amount Received: _____ Date: _____

Received By: _____

Physical Activity Readiness Questionnaire (PAR-Q)

For most people, physical activity should not pose any problem or hazard. The PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable.

- | | | |
|-----|----|---|
| YES | NO | 1. Has your doctor ever said you have heart trouble? |
| YES | NO | 2. Do you frequently suffer from pains in your chest? |
| YES | NO | 3. Do you often feel faint or have spells of severe dizziness? |
| YES | NO | 4. Has a doctor ever said your blood pressure was too high? |
| YES | NO | 5. Has a doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise? |
| YES | NO | 6. Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to? If YES, explain: _____ |
| YES | NO | 7. Are you on any medications? If YES, please explain: _____ |

Signature: _____ Date: _____

APPENDIX E

EXERSTRIDER PROGRAM TEST SCHEDULE

Exerstrider Program Test Schedule (memo)

NAME: _____
Your pre test / post test has been scheduled for:
TIME: _____ a.m. / p.m.
DAY: _____
DATE: _____

Memo:

Please do not exercise 24 hours or eat 3-4 hours prior to your scheduled test time.

At the above time, please come to the Human Performance Laboratory in Mitchell Hall (second floor on the south side) dressed in comfortable exercise clothes (i.e., walking / running shoes, shirt/blouse/tee shirt, etc.). In addition, please bring a swimming suit and towel. These tests should be completed in approximately one and a half hours, but you should plan on two hours "just in case".

If, for any reason, you cannot make the above time, please call 785-8689 as soon as possible. Thank you.

APPENDIX F
TRAINING LOGBOOK

RATE OF PERCEIVED EXERTION (RPE SCALE)

- 6
7 VERY, VERY LIGHT
8
9 VERY LIGHT
10
11 FAIRLY LIGHT
12
13 SOMEWHAT HARD
14
15 HARD
16
17 VERY HARD
18
19 VERY, VERY HARD
20



La Crosse Exercise and Health Program

Exerstrider / Walking Logbook

NAME _____

WEEK _____

♥ TARGET HEART RATE _____

DURATION _____

WEEKLY EXERCISE LOG

	TIME	DISTANCE	♥ HEART RATE ♥			RPE	WHERE	COMMENT
	(MIN)	(MILES)	REST	EXERCISE	RECOVERY			
SUN								
MON								
TUE								
WED								
THU								
FRI								
SAT								

APPENDIX G
TRAINING PROGRESSION

EXERSTRIDER / WALKING TRAINING PROGRESSION AND GUIDELINES

FOR: _____

Where:

- At least 2 of the 4 exercise sessions must be done at the UW-L outdoor track (or indoor track during inclement weather).
- If desired, all exercise sessions could be done at UW-L.
- Any training done off campus (maximum of 2 per week) must be done on level terrain.

Frequency:

- 4 exercise sessions per week must be done.
- Each exercise session must be logged in your personal logbook. These logbooks will be collected and recorded each week.

Intensity:

- Your intensity should be monitored by periodic pulse checks. For a 10 second count, your pulse should be between: _____. In addition to pulse checking, your rating of perceived exertion (RPE) should ideally fall between 12 and 15.

Duration / Progression:

- How long you exercise each session is listed below.

<u>WEEK #</u>	<u>DURATION (min)</u>
1	20 - 25
2	25 - 30
3	30 - 35
4	35 - 40
5	40 - 45
6	40 - 45
7	40 - 45
8	40 - 45
9	40 - 45
10	40 - 45
11	40 - 45
12	40 - 45

Please remember:

- 1) This is a scientific research experiment. We need your cooperation to make this a valid study. Please adhere to the instructions and guidelines that we've given you.
- 2) Don't begin to diet during the study. This will adversely affect the results of our experiment. Maintain your normal diet throughout the 12 weeks of training.
- 3) Maintain the same activity level that you had before the study began, no more, no less.