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ABSTRACT

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The CROSS WALK Dual Motion Cross Trainer (CROSS WALK) (Proform, Logan, UT) is a motorized treadmill designed to increase the energy cost of walking by incorporating arm activity during walking, thus increasing the muscle mass used during exercise. This study investigated the potential increases in exercise intensity and energy cost associated with the use of the CROSS WALK. 37 female S (17-53 yrs) performed a 30-minute submaximal walking test at various speeds on the CROSS WALK. The test consisted of six, 5-min steady-state exercises at 2.0, 3.0, and 4.0 mph, with and without arm activity. The steady-state variables of HR, V_E, VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$, $L \cdot min^{-1}$), METs, kcal, RER, and RPE were analyzed and compared. Dependent t-tests indicated that walking with arm activity significantly ($p < .0001$) increased HR, V_E, VO_2 ($ml \cdot kg^{-1} \cdot min^{-}1$, $L \cdot min^{-1}$), METs, kcal, and RPE. HR responses significantly ($p < .0001$) increased with arm activity 16.8, 25.9, and 31.3 $b \cdot min^{-1}$ at walking speeds of 2.0, 3.0, and 4.0 mph, respectively. The average energy costs increased 35% with the addition of arm activity at all speeds (i.e., 2.0, 3.0, and 4.0 mph). The addition of arm activity increased the MET level by 1.76, 2.43, and 2.87 METs at 2.0, 3.0, and 4.0 mph, respectively. Significant ($p < .0001$) differences were also found for RPE, with an average increase of 14% which paralleled the increase in HR and energy expenditure. It is concluded that the use of the CROSS WALK can increase the intensity of walking at any given speed, and thus may provide additional training benefits to walkers.

ENERGY COST OF WALKING WITH AND WITHOUT ARM ACTIVITY ON THE CROSS WALK DUAL MOTION CROSS TRAINER

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TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Background

The adult population of the United States has been involved in an unprecedented fitness boom for nearly 2 decades (Stone, 1987). Part of this enthusiasm has stemmed from the belief that increased physical activity is beneficial in promoting a healthier lifestyle. The fitness boom has influenced millions of American adults to begin exercise programs.

Walking has emerged as a particularly appealing activity to promote health and fitness (Rippe, Ward, Porcari, & Freedson, 1988). Results of a 1983 survey of 1751 primary care physicians, indicated that walking was by far the most common activity recommended by physicians (cited in Rippe et al., 1988). As a mode of exercise, walking is a convenient, easily regulated exercise. According to the American College of Sports Medicine (ACSM) (1990), any activity that uses large muscle groups, can be maintained continuously, and is rhythmical and aerobic in nature may be used to develop and maintain cardiorespiratory fitness. Walking meets these requirements.

Duncan, Gordon, and Scott (1991) found that increases in cardiorespiratory fitness are related to walking speed. Porcari et al. (1987) reported that 91% of all women and 83%

of all men aged 50 and older reached a target heart rate (i.e., 70% of their maximum heart rate) when walking a mile as fast as possible. For many men and women, however, this would require intensities of effort higher than can be provided at normal walking speeds. In addition, walking involves primarily muscles of the lower body.

Paralleling the growing interest in exercise has been the growth of the fitness equipment industry. New products have been developed in an attempt to increase the intensity of walking. Hand weights have been shown to increase the intensity of walking, but may result in injuries (Stamford, 1984). Exerstriders (i.e., walking poles) have also been shown to increase the energy cost of walking. Babyak, VanHeest, and Rodgers (1991) reported a 12% increase in energy cost when walking 4.2 mph with Exerstriders ($20.5\ ml \cdot kg^{-1} \cdot min^{-1}$) as opposed to walking without them ($18.3\ ml \cdot kg^{-1} \cdot min^{-1}$).

The newly developed CROSS WALK Dual Motion Cross Trainer (CROSS WALK) (Proform, Logan, UT) is a motorized treadmill designed to increase the energy cost of walking by incorporating upper body exercises (i.e., natural arm movement) during walking. This increase in energy cost is potentially important for low fit persons and individuals who cannot run, do not want to run, or are limited in the speed at which they can walk. The use of the CROSS WALK, therefore, may enable certain individuals to exercise at an intensity that can elicit beneficial physiological effects.

Purpose of the Study

The primary purpose of this study was to compare the energy cost of walking on the CROSS WALK with and without arm activity in women between the ages of 17 and 53 years.

Need for the Study

The most widely used aerobic exercises involve predominantly leg work (Graves, Pollock, Montain, Jackson, & OKeefe, 1987). Using the CROSS WALK may increase the intensity of walking through the addition of arm activity. Presently, there are no data available regarding the physiological responses to walking on the CROSS WALK. Knowledge of expected responses might be beneficial to those interested in purchasing home exercise equipment and to those prescribing walking programs. Therefore, this study attempted to determine if there are significant differences in physiological responses (i.e., heart rate, absolute and relative oxygen consumptions, METs, kcal, ventilation volumes, respiratory exchange ratios, and ratings of perceived exertion) between walking with and without arm activity on the CROSS WALK.

Hypothesis

There are no significant differences in physiological responses between walking with and without arm activity on the CROSS WALK Dual Motion Cross Trainer.

Assumptions

Within the limits of this study, it was necessary to make the following assumptions:

1. All subjects were in good health and free of any physical limitations that would prevent exercising on the CROSS WALK.
2. All subjects adhered to preconditions outlined for them prior to testing.
3. One instructional practice session was sufficient to teach the subjects proper techniques while walking on the CROSS WALK, to familiarize the subjects with the test procedures, and to relieve test anxiety.
4. The heart rate monitor accurately determined the subjects' heart rates.
5. The resistance setting on the arm handles remained constant during the testing.

Delimitations

The following delimitations were recognized in this study:

1. All subjects were women between the ages of 17 and 53 years.
2. The practice and testing sessions were completed within 2 weeks.

3. Subjects walked at selected combinations of speed and arm activity (i.e., 2.0, 3.0, and 4 mph, with and without arms).

Limitations

The following limitations were considered:

1. The subjects were volunteers and may not have been representative of the true population.
2. It was not possible to control for learning effect of individuals who had previously used treadmills.
3. The subjects' stride lengths varied due to variation of individual leg length.
4. The subjects' arms did not traverse the same distance while performing the arm movements due to differences in arm length and flexibility.
5. The subjects did not consume the same diets prior to each test session.
6. It was not possible to completely control for slight changes in belt speed.

Definition of Terms

Aerobic Exercise - exercise (e.g., walking) during which the body is able to supply adequate oxygen to working muscles to sustain performance for long periods of time (McArdle, Katch & Katch, 1991).

Cardiorespiratory Endurance - the ability to perform large-muscle, dynamic, moderate-to-high intensity exercise, such as walking, for prolonged periods (ACSM, 1991).

Energy Cost - the amount of energy required by the body to perform an activity. Energy cost was estimated from the oxygen requirements of the exercises in this study and is expressed in $l \cdot min^{-1}$, $ml \cdot kg^{-1} \cdot min^{-1}$, kcals, or in METs.

Heart Rate - the number of times the heart beats per minute as determined by Polar Vantage XL heart rate monitors.

CROSS WALK Dual Motion Cross Trainer (Proform, Logan, UT) - a motorized treadmill designed to increase the energy cost of walking by providing a training stimulus to develop upper body strength by incorporating upper body exercises (i.e., natural arm movement) during walking.

Q-Plex I (Quinton Instrument Company, Seattle, WA) - a programmable, automated, open circuit gas system to determine oxygen and carbon dioxide concentrations. The measures of oxygen consumption, respiratory exchange ratio, and minute ventilation were determined via the Q-Plex I.

Rating of Perceived Exertion (RPE) - a categorical scale which is used as a subjective indicator of the degree of physical strain during a physical activity. The overall rating integrates information, including signals elicited from the peripheral working muscles and joints, from the central cardiovascular and respiratory functions, and from the central nervous system (Borg, 1982).

Respiratory Exchange Ratio (RER) - the ratio of the amount of carbon dioxide produced to the amount of oxygen consumed as measured on the Q-Plex. The RER can be used to estimate the relative proportions of fat and carbohydrate oxidation in exercising muscle.

Steady-State - reflects a balance between the energy required by the working muscles and the rate of ATP production via aerobic metabolism; steady state was determined when the oxygen consumption curve remained at a plateau for the duration of the stage.

Walking Pattern - pattern of movement on the CROSS WALK in which the performed arm motion is synchronized with the swing phase of the opposite leg. The peak of the arm excursion corresponds to the heel strike of the opposite leg.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

Endurance training modalities such as walking, running, or cycling can improve both peak cardiovascular and submaximal cardiovascular efficiency (Auble & Schwartz, 1991). However, these improvements tend to be specific to activities involving muscles of the lower body with little transfer of these effects to the upper body (Franklin, 1989). Yet, most occupational and recreational activities require combined upper and lower body work or, at times, upper body work alone (i.e., gripping tennis rackets, carrying bags and boxes, using house and garden tools, using oars when rowing or poles when skiing, etc.). Ideally, a single exercise modality should cross-train muscles in both the upper body and lower body simultaneously for endurance and strength. The CROSS WALK may be a convenient training modality for this purpose.

Extensive research into the area of upper body exercise has established that a training effect occurs when the upper body is used. The studies involving upper body aerobic exercise have relied heavily on arm ergometry (cranking) and more recently, hand weights. A comparison of the arm movements used on the CROSS WALK with arm ergometry is impractical since the two have little in common, except for the use of arms during exercise. However, some literature on combined arm-leg ergometry has been reviewed.

When using hand weights in aerobic exercise, they are pumped rhythmically to the pace of the activity being performed. Since walking and pumping hand weights is very comparable to exercise on the CROSS WALK (i.e., using upper body handles) a greater emphasis was placed on reviewing literature that studied the aerobic requirements for moving hand weights through various ranges of motion while walking. For these reasons, the review of related literature has been divided into two parts. The first part reviews some of the literature related to the energy cost of walking and the second part reviews the literature related to the energy cost of exercise distributed between the upper and lower body.

Energy Cost of Walking

Fitness walking has become a very popular form of exercise for weight control and improvement of functional aerobic capacity. Walking is a low impact mode of exercise, inexpensive, can be done anywhere, and by almost anyone (McArdle et al., 1991).

Over 30 years ago, Bobbert (1960) and Ralston (1960) demonstrated that the energy cost of walking on a treadmill at 5.86 km per hour (3.6 mph) and 2.93 km (1.8 mph) were no different from normal walking on a hard surface at the same speeds. This indicates that people can generate essentially the same exercise stress either by walking on the level or walking at the same speed and distance on an exercise treadmill.

In 1975, Luria and Koepke studied the physical effects of walking in young adults (22-25 years) who completed a 10 week walking program. Forty-six percent of the subjects demonstrated a training effect, even though their training intensity was below the ACSM (1991) recommendation of 70% maximal heart rate. The authors concluded that the degree of prior physical conditioning may be a factor as to whether or not walking will provide sufficient exertion to elicit training intensities of this level. However, a definite training effect was shown, so they concluded that walking is especially good for poorly physically conditioned individuals, or for those individuals who prefer less strenuous exercise. McArdle et al. (1991) suggested that walking not only produces a training effect for untrained persons at a tolerable workload, but also has a reduced injury rate when compared to running.

Porcari et al. (1987) reported that fast walking on a flat surface was intense enough to elicit a training effect in most women and men over the age of 50. However, the study also revealed that younger men with high VO_2max values experienced difficulty attaining a training heart rate when walking a mile as fast as possible. This finding is in agreement with Luria and Koepke's (1975) conclusion that the level of prior physical conditioning may determine if a training heart rate can be attained through walking alone.

McArdle et al. (1991) also related three basic conclusions with regard to the energy cost of walking: (a) the variability among individuals' caloric cost of walking at the same speed was only 15%; (b) the relationship between walking speed and oxygen consumption is approximately linear between speeds of 3.0 and 5.0 km per hour (1.86 to 3.10 mph); and (c) at faster speeds, walking becomes less efficient and the relationship curves in an upward direction which indicates a greater caloric cost per unit of distance traveled. This finding accounts for the observation that, per unit distance traveled, the total calories expended are greater at the faster, less efficient walking speeds (Fellingham, Roundy, Fisher, & Bryce, 1978).

It has been documented that the energy cost of running 1 km at any speed is approximately twice that of walking 1 km at the most economical speed of 4 km/hr (Bhambani & Singh, 1985; Margaria, Cerretelli, Aghemo, & Sassi, 1963). However, the impact force on the leg while running is equal to about three times the body mass whereas the level of shock with walking is only 30% of this value (McArdle et al., 1991). This might be a reason for the trend in recent years to choose low impact exercise, such as walking, as an effective mode of physical activity.

Due to the difficulty in direct measurement of VO_2, formulas have been developed to estimate the energy cost of walking. These formulas take into account the speed of walking and the weight of the individuals. According to ACSM (1991), VO_2 can be estimated with reasonable accuracy for walking speeds from 1.9 to 3.7 mph. Although VO_2 estimates for walking are relatively accurate for most speeds and grades, there are exceptions. For example, the formula is more accurate in estimating VO_2 when the participant is walking up a grade than on a level. Underestimates of 15 to 20% are expected with level walking, and 5 to 8% with walking up a 3% grade. The walking formula is equally accurate for men and women across the adult age range.

Bobbert (1960) and Workman and Armstrong (1963) estimated the energy cost of walking to be 4.0 and 3.8 $kcal \cdot min^{-1}$, respectively. Although the age, gender, training level, and morphological type of the individual are important when calculating the energy cost of walking, the body weight of the exerciser is considered to be by far the most important of these factors (Bobbert, 1960).

Bhambhani and Singh (1985) did a cinematographic analysis of walking and running in men and women to determine if there was a significant difference between sexes. The gross energy cost per km, net energy cost per km, and the net energy cost per stride revealed no significant differences in each case.

For many men and women the use of ankle weights increases the energy cost of walking to values usually observed for running (Miller & Stamford, 1987). This is beneficial to people who desire to use only walking as a relatively low-impact training modality, yet require intensities of effort higher than can be provided at normal walking speeds. Hand-held weights may also increase the metabolic and physiological cost of walking. This will be discussed more extensively in the following section.

Exercise Distributed Between the Upper and Lower Body

Arm-Leg Ergometry

Stenberg, Astrand, Ekblom, Royce, and Saltin (1967) investigated which combination of arm and leg exercise might be of particular importance in assisting cardiac rehabilitation patients through exercise programs. They demonstrated that using arms and legs was more readily tolerated and accepted by the subjects because the overall stress and subjective physical effort were less. The authors concluded that because more muscle mass was involved in arm and leg work, the feeling of strain must be related more to the metabolic rate per square area of muscle than to the total metabolism of the system.

Bergh, Kanstrup, and Ekblom (1976) studied combined arm and leg ergometry in four different ways: the arms doing 10, 20, 30, or 40% of the total rate of work. They then compared the various combinations of arm and leg ergometry to running and cycling. In arm and leg exercise with an arm work rate of 10-30% of the total rate of work, VO_2max was higher than cycling, but when the arms performed 40% of the work, the VO_2max was the same as cycling. The VO_2max was the same in running as in all combinations of arm and leg exercise. In arm and leg exercise, with 40% of the total work performed as arm work, the subjects stopped due to complete exhaustion of the arm muscles. Bergh et al. (1976) concluded that arm plus leg exercise is influenced by the total ratio of arm work to the total rate of work. They also concluded that exercise at a given oxygen uptake can be maintained for longer periods of time in combined arm and leg exercise compared to leg bicycle exercise.

In contrast, a study by Reybrouck, Heigenhauser and Faulkner (1975) found that different percentages of maximum arm and leg ergometry did not influence VO_2max. A leveling off in VO_2 was observed in each combination of ergometry as a maximum work rate was achieved. The leveling off was more easily obtained during leg and combined arm and leg ergometry than during arm ergometry alone. Most importantly, Reybrouck et al. (1975) found that the anaerobic threshold was reached at progressively higher work rates in arm, leg, and combined arm-leg ergometry. The subjects reached their anaerobic threshold at 65% of VO_2max in arm ergometry, 70% of VO_2max in leg ergometry, and 95% of VO_2max in combined arm-leg ergometry. The difference between the arms and the legs was not significant, but the onset of the anaerobic threshold was clearly delayed in combined arm-leg ergometry.

In addition to the studies that have compared maximal arm-leg ergometry values, several other researchers have investigated the changes that occur at submaximal levels. Mostardi, Norris, and Gandee (1981) compared levels of improvement in aerobic power in order to determine whether levels of conditioning associated with conventional leg work are comparable to those associated with both arm and leg work. One of the important findings was that regardless of the amount of muscle mass used in the conditioning program, the levels of acquired conditioning values (VO_2 and heart rate) were nearly identical. More importantly, the arm and leg group conditioned with much less overall stress on the system.

Toner, Glickman, and McArdle (1990) examined the hemodynamic differences between upper and lower body exercise where the total power output was proportionally distributed between the upper and lower body. They observed that strict upper body exercise elicited a greater increase in heart rate compared with leg exercise at the same power output. However, they also found that when any level of leg exercise was combined with arm exercise, this difference in heart rate was eliminated.

Stenberg et al. (1967) also found that heart rate, blood pressure, and lactate values were all higher for arm work when compared with those during leg work at the same VO_2. This indicates an increased load on the heart and may be due in part to a Valsalva effect inhibiting venous return as well as high perfusion of the arm musculature. However, according to Mostardi et al. (1981), when arm work is used in combination with the legs, the effect is not only beneficial with respect to conditioning and work performed, but also for the subject's overall feeling of well being. Involving the legs in the total exercising muscle mass may reduce the arterial blood pressure by lowering perfusion through the arm muscles. Mostardi et al. (1981) concluded that combined arm and leg ergometry would be most tolerable for unconditioned people because the large muscle mass involvement might enable them to condition up to the levels of fitness that would otherwise be achieved using the legs alone.

The work by Toner, Sawka, Levine, and Pandolf (1983) found that the effect of adding legs to arm cranking facilitates venous return. In addition, dilation of the vascular bed of the legs reduced the myocardial afterload. This reduction in stress on the heart supports the idea that incorporating arm work with leg work can be beneficial.

Toner et al. (1983) also demonstrated that at a moderate power output, the relationship of VO_2 and percent arm values appeared linear, whereas at a high power output the relationship was curvilinear. They concluded that this increase in VO_2 response with increased percent arm values probably resulted from a requirement for body stabilization during combined arm cranking and leg cranking at the moderate power output and from excessive body movements during only arm cranking at the high power output.

Hand Weights

Light hand-held weights have become a popular adjunct to walking. The exerciser holds the hand weights and moves the arms through various ranges of motion. Exercise intensity is varied by changing the range of motion of the arms, legs, or trunk; the size of the hand weights; or the movement frequency of the arms and legs. Rhythmically moving hand-weighted arms through large ranges of motion while walking should require higher VO_2 than those of walking without hand weights or walking while simply carrying hand weights.

Francis and Hoobler (1986) found that walking with 2 and 4 lb. hand weights at 3.5 mph did not significantly alter oxygen consumption. However, they found that running at 5 mph did significantly increase the oxygen uptake by 1.8 ml·kg·min while carrying 2 lb. weights and by 2.7 ml·kg·min while carrying 4 lb. weights. These relatively small but significant increases in oxygen uptake were considered marginal at best and should be weighed against the possibility that additional stress might be placed on the lower extremities.

In contrast, Auble, Schwartz, and Robertson (1987) found that VO_2 required for walking while pumping hand weights was greater than that required for normal walking, and the cost increased as the pump height, hand weight, and walking speed increased. In this study, the hand weights were pumped throughout a much greater range of motion than that of Francis and Hoobler (1986) in which the hand weights were simply held. These greater pump heights most likely increased the energy cost through greater upper body muscle involvement.

Owens, Ahmed, and Moffatt (1989) predicted that significant increases in VO_2 and heart rate might be attained with normal arm swing patterns if a slightly heavier load were used. However, their results suggested that walking with hand-held weights of 2.27 kg or less, while maintaining a normal arm swing, was not a sufficient stimulus to significantly increasing VO_2 or heart rate.

Work by Graves et al. (1987) reported that heart rate, VO_2, ventilation volume, blood pressure, respiratory exchange ratio, and rating of perceived exertion all increased significantly when hand weights were added to walking exercise performed at constant treadmill speed and grade. The subjects in this study were able to attain a training intensity of 60% HRmax reserve, which corresponded to an oxygen cost of approximately 25.2 $ml \cdot kg^{-1} \cdot min^{-1}$ or 7.2 METs. A walking speed greater than 5.0 mph at 0% grade would be required to produce such an oxygen cost without hand weights. Even healthy persons might have difficulty walking at speeds above 5.0 mph. Franklin (1989) suggested that the increased energy expenditure caused by swinging hand weights during walking can produce metabolic loads comparable to those of slow jogging while also providing an upper extremity workout.

Maud, Stokes, and Stokes (1990) further investigated oxygen uptake, heart rate, rating of perceived exertion (RPE), and stride frequency response to carrying hand-held weights, particularly as related to the contribution of arm swing range to increases in oxygen cost. They also studied the effects of degree of arm swing and hand loading on freely chosen stride frequency. They found that vigorous arm swing alone was sufficient to increase oxygen cost but the addition of hand weights further increased this expenditure. However, the addition of vigorous arm swing and/or hand weights also resulted in an increase in stride length, which in itself may affect the energy cost. Significant differences existed between male and female subjects with the female subjects having the higher values in oxygen consumption and heart rate responses under all conditions tested. Female stride frequency responses were significantly greater than male responses for all conditions but the hand-weighted condition. Females also perceived the exercise to be more stressful.

Graves et al. (1987) found an increase in systolic and diastolic blood pressures associated with hand-weighted exercise. They stated that this may be due to an increased isometric exercise component. These data suggest that hand weights may be beneficial for healthy individuals who wish to increase the intensity of walking exercise, however, the use of hand weights may be contraindicated in patient populations affected by an exaggerated blood pressure response to exercise.

Abadie (1990) investigated whether walking with wrist weights, which do not require an isometric contraction, would create significantly different physiological responses when compared to the same workload with hand weights and walking with no additional weights. The increase in energy expenditure during the wrist-weighted walking (3 lbs each) and the hand-weighted walking treatments represented a 16.2 and 12.4% increase in the relative VO_2, respectively. Contrary to the results of the hand-weighted walking treatment, the wrist-weighted walking treatment did not result in a significant increase in diastolic blood pressure when compared to the nonweighted treatment. The author concluded that the lack of an increase in diastolic pressure during wrist-weighted walking was due to the lack of an isometric contraction of the hands.

Poles

Exerstriders, specially designed walking poles, were also developed in an attempt to increase the energy cost of walking. The simultaneous movement of the arms and legs while using these poles might be comparable to the walking pattern while using the newly developed CROSS WALK. Babyak et al. (1991) reported that the use of the Exerstriders caused a significant increase in oxygen uptake, heart rate, kcal, and respiratory exchange ratio compared to normal submaximal treadmill walking. It was postulated that these changes were likely due to the increased contribution of the upper body during Exerstriding.

Summary

Recent interest in physical fitness has led to the development of novel forms of aerobic exercise. An example is the newly developed CROSS WALK. The CROSS WALK proposes to: 1) increase the energy cost of treadmill walking by providing a stimulus for combined upper and lower body endurance; and, 2) to strengthen muscles of the upper torso. Most training modalities used to improve fitness levels have been lower leg activities, yet arm cycling has been shown to elicit training effects. Hand-weighted exercise, which might be comparable to exercise on the CROSS WALK, has been suggested to increase energy costs, however, the energy costs and cardiovascular responses have varied between investigations. Some studies demonstrate no effect on energy costs and others a substantial effect. Some advise caution when prescribing hand weights because of a possible pressor reflex caused by isometric contraction of the hand weight. Knowledge of the energy cost of the CROSS WALK as well as any contraindications would provide information on which to base safe and effective exercise.

CHAPTER III

METHODS

Introduction

The methods in this chapter were developed to compare the energy cost of walking with and without arm activity on the CROSS WALK Dual Motion Cross Trainer. The equipment used and the calibration procedures are discussed in this chapter. The exact operational procedures of the study include subject selection, pilot study, practice sessions, experimental sessions, and statistical treatment of the data.

Pilot Study

A pilot study was conducted to standardize the equipment and to determine the exact testing procedures. Eight women between the ages of 18 and 34 years were tested in the pilot study. Each exercise session consisted of walking with and without arm activity at various combinations of speed (i.e., 2.0, 3.0, 4.0, and 5.0 mph) and grade (i.e., 3 and 10% grades). Changes in the proposed testing methods were made under the direction of the thesis chairperson. These changes consisted of reducing the walking speeds from 3.0, 4.0, and 5.0 mph, to 2.0, 3.0, and 4.0 mph; selecting only one grade elevation (i.e., 3% grade) rather than two different elevations (i.e., 3 and 10% grades); and randomly selecting the arm activity sequence (i.e., with and without arms). The highest resistance setting was selected for the arm activity since this allowed for easier calibration and greater control during the test. From this pilot study, testing procedures were finalized and implemented. The data collected from the pilot study were not analyzed statistically, and are not presented in this paper.

Subject Selection

The subjects for this study consisted of 37 women of various fitness levels between the ages of 17 and 53 years. All of the subjects volunteering for this study were from LaCrosse, WI and the surrounding area. All subjects were considered in good health and free of any known cardiovascular, respiratory, or orthopedic conditions that might preclude participation in this study. For scheduling purposes, a number of times were set up and each subject was able to choose a convenient time. Each subject was scheduled for one practice session and one testing session. All subjects were instructed to refrain from caffeine, eating, smoking, and drinking alcoholic beverages for at least 4 hours prior to each test. In addition, the subjects were advised on proper clothing to wear and were instructed not to perform any strenuous exercise on the same day of the test prior to being tested. Prior to the time of the test, each subject signed an informed consent form (see Appendix A), explaining the nature of the study and any risks involved.

Practice Session

Each subject completed at least one practice session on the CROSS WALK before the actual testing began. A demonstration was given by the researcher and included: (a) how to get on and off of the treadmill; (b) how to straddle the treadmill prior to starting the test; (c) correct head position and correct walking pattern; (d) correct form and technique for using the upper body handles; (e) a verbal explanation of the Borg Scale of Perceived Exertion (see Appendix B); (f) a description of the heart rate monitor; and, (g) a description of the breathing techniques and gas collection procedures. Subjects then practiced walking on the CROSS WALK with and without the upper body handles at various speeds and grades. Each subject practiced walking without headgear and with headgear until they felt comfortable.

Testing Procedures

Upon arrival at the Human Performance Laboratory, each subject was measured in their exercise clothes for height and weight. The values were recorded to the nearest .25 cm and to the nearest .25 kg, respectively. The subject was instructed to do some warm up stretches before beginning the test.

The Q-Plex I (Quinton Instrument Company, Seattle, WA) was calibrated prior to each testing session using gases of a known percentage previously determined by the Micro-Scholander technique. The Q-Plex was calibrated within .01 for oxygen and carbon dioxide percentages. Temperature and barometric pressure were adjusted accordingly. The flow meter volume was calibrated using a 3.002 liter syringe pump at various flow rates.

Prior to each test session, the CROSS WALK was calibrated. Calibration was done by measuring the number of revolutions of the treadmill belt per minute. The treadmill was then set at the required speeds and checked for accuracy and consistency at each stage in order to keep the speed at the initial setting. Modifications were made as necessary throughout the test. The degree of incline was calibrated using a level and a meter stick. The resistance setting of the upper body handles was checked for consistency prior to each test using a tension gauge.

Heart rates were monitored by using Polar Vantage XL heart monitors. The heart monitor comes with a wrist-watch display that senses the electrical signals generated by the heart. It electronically computes and displays the heart rate in beats per minute. A transmitter connected to an electrode strap was moistened and placed on the subject's chest below the breasts. Each subject was then fitted for a headpiece, mouthpiece, and nose clip, and was instructed to practice breathing with the entire apparatus. A plastic hose was then connected to the mouthpiece at one end and to the Q-Plex I at the other end. Before the test, explicit instructions regarding the use of the Borg Scale of Perceived Exertion were presented as follows:

> I will be using this scale so that you may translate into numbers your feelings of exertion while exercising. The range of numbers should represent a range of feelings from "No Exertion at all" (number 6) to "Maximal Exertion" (number 20). In order to help you select a number which corresponds to your subjective feelings every other number has an attached verbal expression (e.g., 7 is associated with feelings of Very, Very Light Exertion, while 19 is associated with feelings of Very, Very Hard Exertion). Your goal is to rate your feelings which are caused by the difficulty of each workload. These feelings should be general, that is about the body as a whole. I will not ask you to specify the feeling but to select a number which most accurately corresponds to your perception of your total body feeling. Keep in mind that there are no right or wrong numbers. Use any number you think is appropriate.

The Rating of Perceived Exertion (RPE) was used to evaluate the level of exertion during the last minute of each stage throughout the test. Each test session consisted of six, 5-minute steady-state exercises at 2.0, 3.0 and 4.0 mph, with and without arm activity. The subject walked at each speed for 10 minutes (i.e., 5 minutes with arm activity and 5 minutes without arm activity) for a total test time of 30 minutes. The order of arm activity at each speed was randomly assigned, but the speed sequence was consistent.

During the test, heart rates were recorded during the last 15 seconds of each stage and the respiratory gas values of minute ventilation (V_E), $\dot{V}O_2$ ($l \cdot min^{-1}$), VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$), kcal, and respiratory exchange ratio (RER) were determined each minute throughout all tests. The values obtained during the last minute of each steady-state period were used in the actual data analysis.

Statistical Treatment of Data

Means, standard deviations, and ranges were calculated for age, height, weight, and the steady-state variables of heart rate, RPE, V_E, VO_2 ($l \cdot min^{-1}$), VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$), RER, kcal, and MET level. The heart rate and respiratory gas values were determined by taking the values obtained during the last minute of the steady-state period. The oxygen consumption values were converted to METs by dividing VO_2 $ml \cdot kg^{-1} \cdot min^{-1}$ by 3.5 $ml \cdot kg^{-1} \cdot min^{-1}$, which is equal to one MET. Dependent t-tests were computed for each physiological variable to determine if a significant ($p < .05$) difference existed in any of the responses between the exercise with and without arm activity.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

The purpose of this investigation was to compare the energy cost of walking on the CROSS WALK Dual Motion Cross Trainer (CROSS WALK), with and without arm activity in women between the ages of 17 and 53 years. Thirty-seven female volunteers from the La Crosse, WI area each performed a 30-minute submaximal walking test at various speeds on the CROSS WALK. The test consisted of six, 5-minute steady-state exercises at 2.0, 3.0, and 4.0 mph, with and without arm activity.

Data were collected and recorded every minute throughout all tests. The results were analyzed using simple data description and dependent t-tests. The ($p < .05$) level of significance was used to accept or reject the null hypothesis.

The subject characteristics and a discussion of the physiological variables are presented in this chapter.

Subject Characteristics

The subjects' mean age, weight, and height, along with the standard deviations and ranges are presented in Table 1.

Table 1. Means, standard deviations, and ranges of physical characteristics of subjects (*N* = 37)

Variable	Mean	SD	Range
Age (yrs)	23.9	6.9	17.0 - 53.0
Ht (cm)	168.8	5.6	157.5 - 185.4
Wt (kg)	65.1	4.3	51.1 - 96.8

Results

The steady-state variables of heart rate (HR), oxygen consumption (VO_2 $ml \cdot kg^{-1} \cdot min^{-1}$ & $L \cdot min^{-1}$), ventilation (V_E), respiratory exchange ratio (RER), kilocalories (kcal), metabolic equivalents (METs), and rating of perceived exertion (RPE) were analyzed and compared. These values were obtained for each speed (i.e., 2.0, 3.0, and 4.0 mph) with and without arm activity. The treadmill grade remained constant at 3% grade. These values are presented in Table 2.

Walking with arm activity resulted in significantly higher ($p < .0001$) values for V_E, VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$ & $L \cdot min^{1}$), HR, METS, kcal, and RPE compared to walking without arm activity at all speeds (i.e., 2.0, 3.0, and 4.0 mph). There was no significant ($p > .05$) difference between RER at 2.0 mph, however, at 3.0 and 4.0 mph the RER were significantly ($p < .001$) higher during arm activity.

Table 2. Means and standard deviations of the physiological variables at 3% grade and speeds of 2.0, 3.0, and 4.0 mph, with and without arm activity (N=37)

Variables	2.0 mph With	2.0 mph Without	3.0 mph With	3.0 mph Without	4.0 mph With	4.0 mph Without
V_E	29.34^{a**} 3.94^{b}	21.61^{**} 3.05	38.64^{**} 4.25	26.41^{**} 3.24	54.35^{**} 5.99	36.33^{**} 4.50
VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$)	17.66^{**} 2.01	11.54^{**} 1.19	23.61^{**} 2.58	15.10^{**} 1.51	31.39^{**} 2.79	21.35^{**} 2.35
VO_2 ($L \cdot min^{-1}$)	1.14^{**} 0.14	0.75^{**} 0.10	1.53^{**} 0.17	0.98^{**} 0.12	2.02^{**} 0.22	1.40^{**} 0.20
HR (bpm)	113.05^{**} 12.02	96.24^{**} 11.94	132.05^{**} 13.57	106.11^{**} 12.59	155.71^{**} 15.09	124.37^{**} 15.40
METS	5.04^{**} 0.58	3.28^{**} 0.30	6.75^{**} 0.74	4.31^{**} 0.43	8.97^{**} 0.80	6.10^{**} 0.67
Kcal	5.56^{**} 0.67	3.61^{**} 0.48	7.51^{**} 0.85	4.77^{**} 0.60	10.06^{**} 1.08	6.77^{**} 0.96
RER	0.86 0.05	0.87 0.05	0.89^{*} 0.04	0.87^{*} 0.05	0.94^{**} 0.04	0.88^{**} 0.05
RPE	8.43^{**} 1.71	7.24^{**} 1.36	10.59^{**} 1.64	9.03^{**} 1.72	13.03^{**} 1.98	11.63^{**} 1.75

Note. * = $p < .001$ ** = $p < .0001$

a = mean
b = standard deviation

Discussion

HR Response

The addition of arm activity to normal walking at any given speed increased the HR response. This was expected since the addition of arm activity increases the physical workload on the heart. Borysyk et al. (1981) reported increases in HR response of 6.7, 10.5, and 10.1 $b \cdot min^{-1}$ with the addition of arm swings and 12 ounce hand weights at walking speeds of 2.0, 3.0, and 3.5 mph, respectively. Borysyk et al. (1981) concluded that these changes in HR occurred at an intensity that could produce a training effect in sedentary and cardiac populations. The observed increases in HR responses with the addition of arm activity of 16.8, 25.9, and 31.3 $b \cdot min^{-1}$ at walking speeds of 2.0, 3.0, and 4.0 mph, respectively, which are considerably greater increases than Borysk et al. found with hand weights. These higher HR intensities could provide sufficient intensity to produce a training effect. The increases in HRs noted in this study were solely attributed to the addition of arm activity.

V_E Response

There were significant differences in V_E between walking with and without arm activity at all speeds (i.e., 2.0, 3.0., and 4.0 mph). When arm activity was added to normal walking, V_E was 26%, 31%, and 33% higher than walking without arm activity at 2.0, 3.0, and 4.0 mph, respectively.

Such increases augment the air supply; thus, providing the available oxygen for extraction, which the body needs when performing exercises of increasing intensity. This is supported by Borysyk et al. (1981) who noted significant increases in the volume of air exchanged when walking at 2.0, 3.0, and 3.5 mph while carrying hand weights, compared to walking without hand weights at the same speeds. Graves et al. (1987) also reported significantly greater increases in V_E when adding hand weights to walking exercises performed on a treadmill at a constant speed and grade.

Energy Expenditure

No matter what unit was used to express energy expenditure (VO_2 $ml \cdot kg^{-1} \cdot min^{-1}$, VO_2 $L \cdot min^{-1}$, kcals, and METs), similar results were revealed for all exercise comparisons. Arm activity values were significantly higher than those without arm activity at any given speed. According to the ACSM (1991), normal walking at 2.0 mph requires approximately 2.53 METs. Due to treadmill limitations in the present study, it was necessary to combine normal walking at 2.0 mph with a 3% incline. According to the ACSM (1991) metabolic formula, this would require 3.36 METs. The actual value for normal walking at 2.0 mph and 3% grade without arm activity was 3.28 METs. The addition of arm activity, at 2.0 mph and 3% grade, produced an increase in energy expenditure from 3.28 METS to 5.04 METs without any increase in speed. Similar increases in energy expenditure with the addition of arm activity were also evident at 3.0 and 4.0 mph. The observed increase in energy expenditure with the addition of arm activity was found to be 1.76, 2.44, and 2.87 METs at walking speeds of 2.0, 3.0, and 4.0 mph, respectively.

The results of the present study indicated that at any given speed (i.e., 2.0, 3.0, and 4.0 mph) the addition of arm activity increased the MET level of the activity by approximately 35%.

In support of these findings, Auble et al. (1987) found that VO_2 required for walking while pumping hand weights was greater than that required for normal walking, and it increased as the pump height, hand weight, and walking speed increased.

Maud et al. (1990) further investigated the responses to carrying hand-held weights and found that vigorous arm swing alone was sufficient to increase VO_2 by 10%, but when both hand weights and vigorous arm swing were combined, there was an even greater increase of 33% to the overall energy cost.

In addition, Graves et al. (1987) reported that the addition of 1- and 3-lb hand weights to submaximal exercise performed between 60 and 80% of HRmax reserve significantly increased the measures of HR, V_E, VO_2, BP, RER, and RPE.

However, controversy does exist as to whether VO_2 increases or does not change when arm activity is added to leg activity. Reybrouck et al. (1975) found that different percentages of arm cranking and leg cycling did not influence total VO_2. Several other researchers (Francis & Hoobler, 1986; Owens et al. 1989) concluded that walking with hand-held weights is not a sufficient stimulus to significantly increase VO_2 or HR.

Duncan et al. (1991) found that increases in VO_2 are related to walking speed. The American College of Sports Medicine (1991) reports that walking faster than 3.7 mph increased energy cost in a curvilinear fashion. Since the speed of walking directly alters the pumping rate of the arms, a more rapid speed of walking will produce a greater rate of arm movement and an increase in energy expenditure.

However, increasing walking speed in an attempt to increase energy expenditure may not be an appropriate approach, particularly for low fit persons and individuals who cannot run, do not want to run, or are limited in the speed at which they can walk.

An interesting finding in the present study might prove beneficial to those individuals with limited capabilities (e.g., sedentary, arthritic, elderly, and cardiac patients). These data show that the addition of arm activity at a lower walking speed will elicit a greater MET level than that achieved with a faster walking speed and no arm activity. For example, the MET level at 2.0 mph with arm activity was 5.04 METs, while the MET level at 3.0 mph without arm activity was only 4.31 METs. These data suggest that an individual who cannot walk as fast as another individual may be capable of achieving the same energy expenditure through the addition of arm activity.

A result of this increased energy expenditure is an increase in the number of calories burned. The addition of arm activity produced a 35% increase in caloric expenditure at any given speed (i.e., 2.0, 3.0, and 4.0 mph) which might be beneficial to those individuals that are overweight. In addition, the caloric expenditure at 2.0 mph with arm activity (5.56 kcal) was 14% greater than the caloric expenditure at 3.0 mph without arm activity (4.77 kcal). The caloric expenditure at 3.0 mph with arm activity (i.e., 7.51 kcal) was 9.8% greater than the caloric expenditure at 4.0 mph without arm activity (i.e., 6.77 kcal). These data suggest that an individual trying to lose weight might be more successful if they walked at a slower speed with the addition of arm activity rather than simply increasing their walking speed.

Franklin (1989) has suggested that the increase in energy expenditure caused by swinging hand weights during walking can produce metabolic loads comparable to those of slow jogging while also providing an upper extremity workout. The results of the present study support this concept.

According to ACSM (1991), the MET values which are appropriate and beneficial for Phase II cardiac rehabilitation patients are between 3 and 6 METs. The MET values obtained in this study at 2.0 and 3.0 mph, with 3% grade were within the acceptable range for these individuals. An important benefit of using the CROSS WALK for cardiac patients is the incorporation of the upper body into the exercise program, since the arms are often neglected during aerobic exercise. Fardy, Webb, and Hellerstein (1977) stated that arm training was necessary if individuals were expected to return to their original vocation and recreational activities. Training with the upper and lower extremities can be of benefit to the healthy exerciser as well.

RPE

The RPE, rating of perceived exertion, is a subjective rating system (see Appendix B) which grades the difficulty of the physical task being performed (Borg, 1982). When evaluating the RPE responses, the comparison of walking without arm activity to walking with arm activity indicated a 14% increase in the RPE values. The relationship of RPE and VO_2 is presented in Figure 1. Even though the RPE at each speed was higher with the addition of arm activity, for a given VO_2 the RPE was lower when the arms were incorporated into the activity. This suggests that the individual's perception of effort was lower with combined arm and leg activity than with walking alone. Since HR and energy expenditure are standard means of gauging exercise

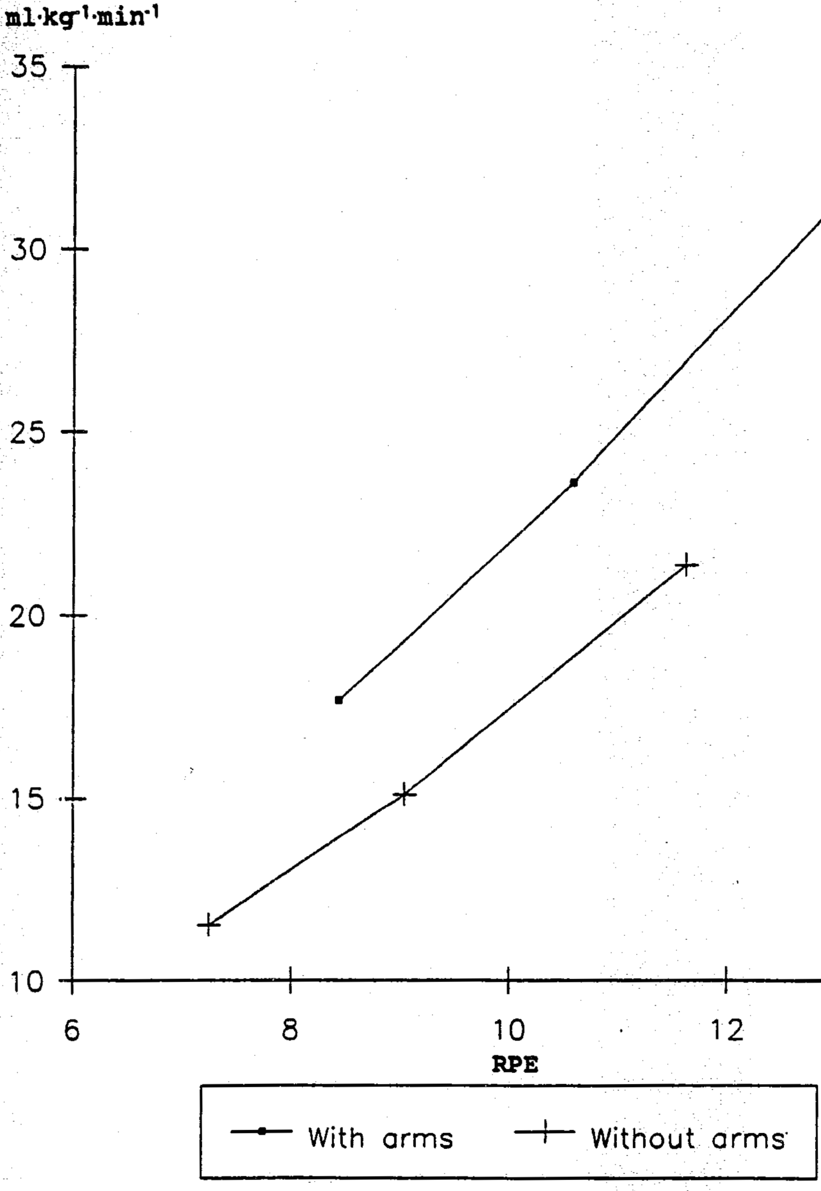

Figure 1. RPE vs. VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$) when walking on the CROSS WALK Dual Motion Cross Trainer with and without arm activity

intensity, RPE can also be used to accurately assess exercise intensity while walking on the CROSS WALK. This may be of particular importance when prescribing exercise for the cardiac patient because many medications may affect cardiorespiratory and/or metabolic responses to exercise. Since RPE has been shown to be a reliable and valid measure of intensity of training in patients taking beta blockers, RPE may provide an alternative method for monitoring exercise (Franklin, 1985). Rating of Perceived Exertion may be especially useful in situations in which medications and dosages are changed frequently and maximal exercise testing is not feasible. Rating of Perceived Exertion may also be suggested if an individual has difficulty taking his/her pulse during exercise. Generally, an RPE of 13 to 15 corresponds to approximately 70-85% HRmax (Ward, Malloy, & Rippe, 1987).

Summary

The findings in the present study indicate that walking on the CROSS WALK can increase the aerobic metabolic requirements above those for normal walking. Results showed that there were significant ($p < .0001$) differences in VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$ & $L \cdot min^{-1}$), METs, V_E, HR, and RPE with the addition of arm activity as compared to walking without arm activity. The average increase in energy expenditure was 35%. The addition of arm activity produced similar results for RPE and HR, therefore either measure may be used to assess the intensity level for exercise on the CROSS WALK. There were also significant ($p < .05$) differences in RER with the addition of arm activity. The MET values obtained in this study ranged from 3.27 to 8.96. The MET levels at 2.0 and 3.0 mph would be appropriate for individuals in a Phase II cardiac rehabilitation program. In addition, when converting the energy cost of walking to kcals, a 35% increase in caloric expenditure was found at all speeds (i.e., 2.0, 3.0, and 4.0 mph). The energy cost values of walking with arm activity at 2.0, 3.0, and 4.0 mph all exceeded the 4.3 $kcal \cdot min^{-1}$ cost of walking at 3.0 mph, which may be of benefit in weight reduction programs.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to explore the potential differences in VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$ & $L \cdot min^{-1}$), V_E, HR, METs, kcal, RER, and RPE while walking on the CROSS WALK, with and without arm activity.

Thirty-seven female volunteers from the La Crosse, WI area each performed a 30-minute submaximal walking test at various speeds on the CROSS WALK. The test consisted of six, 5-minute steady-state exercises at 2.0, 3.0, and 4.0 mph and 3% grade, with and without arm activity.

Statistical analyses were performed to determine if significant differences existed among the variables of VO_2, V_E, HR, METs, kcal, and RPE when comparing walking with arm activity to walking without arm activity. The level of significance was set at the .05 level.

Significant ($p < .0001$) differences were found between the variables of V_E, VO_2, HR, METs, kcal, and RPE at all speeds. The observed increase in energy expenditure with the addition of arm activity was found to be 1.76, 2.44, and 2.87 METs at walking speeds of 2.0, 3.0, and 4.0 mph, respectively. These results indicate that at any given speed (i.e., 2.0, 3.0, and 4.0 mph), the addition of arm activity increases the level of energy expenditure by approximately 35%. The HR responses were 15, 19, and 20% greater with arm activity, respectively. Additionally, walking with arm activity produced significantly higher RPE values than walking without arm activity. Respiratory Exchange Ratio was significantly different ($p < .001$) at 3.0 and 4.0 mph, but not at 2.0 mph ($p > .05$).

Conclusions

The newly developed CROSS WALK could increase the energy cost of walking by incorporating arm activity during walking. This increase in energy cost is potentially important for low fit persons and individuals who cannot run, do not want to run, or are limited in the speed at which they can walk. Use of the CROSS WALK could produce a training effect sufficient for utilization in Phase II cardiac rehabilitation. In order to produce a training effect an individual would have to workout at an intensity estimated at 40 to 85% of their functional capacity (ACSM, 1990).

In this study, the MET levels ranged from 3.27 to 8.96. An average increase in energy expenditure of 35% was observed when arm activity was added. The CROSS WALK could potentially cross-train muscles in both the upper body and lower body simultaneously for endurance and strength.

Guidelines for a CROSS WALK Training Program

1. The frequency of training with the CROSS WALK should be 3 to 5 days per week in accordance with ACSM guidelines (1990). It is recommended that a person who wishes to use the CROSS WALK as a means of exercise should start out with the least amount of arm resistance available, and gradually increase the arm resistance, speed, and/or grade as the person's functional capacity increases.
2. Participants should set an intensity level that is suitable to this individual fitness levels. The initial stage of CROSS WALK exercise should include low levels of walking in which the participant experiences a minimum of muscle soreness, and avoids debilitating injuries or discomfort. Asymptomatic adults could exercise at an intensity between 60 and 90% of the functional capacity while individuals with low functional capacities should initiate the conditioning program at 40 to 60% of their functional capacity (ACSM, 1990). The intensity of the exercise may be prescribed by METs, HR, or RPE.
3. The duration of the CROSS WALK exercise should begin with sessions of 5 to 10 minutes to reduce the risk of injury to the upper body. This will allow the individual the opportunity to acclimatize themselves to the CROSS WALK. Modification of duration should be individualized on the basis of toleration of the

activity. Total time of the activity should range between 15 and 60 minutes for optimum effect (ACSM, 1990).

4. The progression for CROSS WALK exercise should follow a slow and safe sequence which corresponds to an appropriate MET level.
5. To insure that proper exercise intensity is maintained the exerciser should monitor the HR response closely. The individual should also use a walking speed that is comfortable.

Recommendations for Future Study

1. To help establish the CROSS WALK as a safe exercise mode, particularly for sedentary and cardiac patients, a study evaluating electrocardiographic and hemodynamic changes during arm activity should be undertaken.
2. A longitudinal study should be conducted to determine the effectiveness of CROSS WALK training on cardiovascular fitness levels as well as strength increases.
3. A similar investigation with varying combinations of speed and grade, particularly running speeds and/or higher elevations should be attempted.
4. A less homogenous group could be used. A sample including a wider range of fitness levels may produce different results. The subject population utilized for

this study was made up of volunteers and may not be representative of the true population.

5. In order to test the effectiveness of the CROSS WALK for evaluating VO_2max values, a study might compare a VO_2max test on a conventional treadmill without arm activity to a VO_2max test on the CROSS WALK with the addition of arm activity.

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APPENDIX A

INFORMED CONSENT FORM

CROSS WALK
INFORMED CONSENT

I,____________________, volunteer to participate in a study comparing the energy cost of walking on a CROSS WALK Dual Motion Cross Trainer at 2.0, 3.0, and 4.0 mph, with and without using my arms. Prior to the actual test, at least one practice session will be required on the CROSS WALK to become familiar with the exercise and the data collection procedures. The actual testing session will consist of walking for 5 minutes at speeds of 2.0, 3.0, and 4.0 mph with and without hands (testing sequence will be randomly assigned). The total time for the test will be 30 minutes.

During the test I will be breathing room air through a mouthpiece so that my exhaled air can be collected for analysis. Throughout the test my heart rate will also be monitored continuously via an electrode strap fitted around my chest.

As with any exercise this test involves some risks. I may experience dizziness or unsteadiness while walking on the CROSS WALK and performing the arm activity. Due to this unsteadiness, I may slip or fall while walking on the CROSS WALK. Wearing the breathing apparatus may cause throat irritation and dryness of the mouth. The arm activity may produce muscular soreness due to the added resistance of the upper body handles. In addition, I may feel tired at the end of the test. Any unusual or uncomfortable signs and symptoms should be reported to the researchers immediately. In the event of any abnormal physiological responses, the test will be immediately terminated.

My individual information obtained during the laboratory testing will be kept confidential, however, I will be informed of my specific results as well as the group's means and standard deviations.

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 exercise tests as described above. I have read the foregoing and I understand what is expected from me. I accept the risks associated with the testing procedures as described above with no liability against the researchers, Dr. N.K. Butts, Kelly Knox and T. Shane Foley, the University of Wisconsin-LaCrosse, or any staff involved. Any questions which have risen prior to or during the reading and discussion of this consent form have been answered to my satisfaction. I, therefore, voluntarily consent to be tested. Furthermore, I know I may withdraw from these tests at any time.

Signed:________________________________Date:__________________

Witness:_______________________________Date:__________________

APPENDIX B

BORG SCALE OF PERCEIVED EXERTION

BORG SCALE 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