ABSTRACT

KARAWAN, A. <u>The effects of twelve weeks of walking or Exerstriding on upper body muscular strength and endurance</u>. MS in Adult Fitness/Cardiac Rehabilitation, 1992, 92pp. (J. Porcari)

This study determined potential changes in upper body muscular strength and endurance as a result of walking with the use of specially designed walking poles (Exerstriders). Ninety-two inactive females, 20-49 yrs, volunteered to participate in the study. Ss were randomly assigned to one of three groups: Exerstriders (E), who walked using the Exerstriders; Walkers (W), who participated in a conventional walking program; and Controls (C). E and W participated in a supervised 12-week walking program, exercising 4 days per week, for 20-45 min per session, at 70-85% of maximal HR. Ss were assessed for upper body muscular strength and endurance before and after training. Strength (lb) was assessed using 1-RM tests for triceps pushdown and a modified lateral pulldown exercise. To assess muscular endurance, Ss performed a 1 min bout of alternating arm pulls on a modified Biokinetic Swim Bench apparatus. Total work output (kpm) was used as the criterion measure. Changes in muscular strength and endurance were analyzed with repeated measures ANOVA and Tukey's post-hoc tests. E had sig ($p<.01$) increase (37%) in muscular endurance from pre to posttesting, which was greater than the non sig ($p>.01$) increases shown by W (14%) and C (5%). There were no sig ($p>.01$) changes in pushdown or pulldown strength in any group. It would appear that although Exerstriding can result in substantial increases in muscular endurance, it may not provide sufficient stimulus to increase strength. A longer training period may be needed to alter this parameter.

THE EFFECTS OF TWELVE WEEKS OF WALKING OR EXERSTRIDING ON UPPER BODY MUSCULAR STRENGTH AND ENDURANCE

A THESIS PRESENTED

TO

THE GRADUATE FACULTY

UNIVERSITY OF WISCONSIN-LA CROSSE

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE

MASTER OF SCIENCE DEGREE

BY

ARIEL KARAWAN

MAY 1992

COLLEGE OF HEALTH, PHYSICAL EDUCATION, AND RECREATION
UNIVERSITY OF WISCONSIN-LA CROSSE

THESIS FINAL ORAL DEFENSE FORM

Candidate: **Ariel Karawan**

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

Master of Science, Adult Fitness/Cardiac Rehabilitation

The candidate has successfully completed his final oral examination.

Thesis Committee Chairperson Signature — Date 3-25-92

Thesis Committee Member Signature — Date 3-25-92

Thesis Committee Member Signature — Date 3/25/92

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

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Dean of UW-L Graduate Studies — Date 26 May 1992

ACKNOWLEDGEMENTS

This is the "grand finale" and the last stage in a long journey that I began in June, 1990.

I would like to extend a special thanks to my chairperson, instructor, advisor, and friend, Dr. John Porcari. Thank you John for your time, guidance, and belief in me. I will miss you, John!

Thanks to my committee members, Dr. Nancy Butts, who inspired me throughout the entire program and Dr. Denis Fater, for his time and support.

Thank you to Dr. Phil Wilson, for giving me the green light to participate in this outstanding Adult Fitness/Cardiac Rehabilitation Program.

A special thanks to the following people:

My fellow researchers, Anne-Marie Postmus, Jim Larkin, and Laurie Stoughton, with whom I spent long hours testing and supervising the enthusiastic La Crosse women who participated in our study;

My fellow students in the Adult Fitness/Cardiac Rehabilitation Program class of 1991;

The extraordinary participants of the La Crosse Exercise and Health Program (thanks for your support during the Gulf War);

The dear librarians of the Lutheran Hospital Library in La Crosse, who helped me so much in my search for references;

Lisbeth Reynertson and the staff of the office of International Education, for always being there for me;

Joan Chernock of Santa Fe, New Mexico for her talent, enthusiasm, and great skill in the final editing and shaping of this project;

And last, but certainly not least, heartfelt thanks to Keren and Simcha Prombaum, my light and joy, for opening their hearts and their home to us during our stay in La Crosse.

DEDICATION

I would like to dedicate this thesis to my wife, Lynn, whose devotion, help and support will long be remembered; to my family in Israel - my father, Yeshayahu Karawan (Blessed be his memory), my mother, Eva Karawan, and my sister, Yona Karawan-Ben Netanel; to my in-laws, Clarone and Harold Tolmas.

Thank you all for always being there for me. I will never forget it!

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CHAPTER I

INTRODUCTION

Background

The health advantages of exercise are many: the prevention of coronary heart disease, maintenance of optimal body weight, improved psychological status, a decreased risk of Type II diabetes, and increased bone density are but a few of these advantages (Morris, Pollard, Everitt, & Chave, 1980; Paffenbarger, Hyde, Wing, & Steinmetz, 1984; Salonen, Puska, & Tuomilehto, 1982). Paffenbarger, et al. (1984) suggested that the benefits of physical activity may not be limited to primary prevention of coronary heart disease. They also showed that persons who exercise have a lower incidence of stroke, respiratory disease, all cancers, and deaths than persons who do not exercise.

Haskell, Montoye, and Orenstein (1985) found that the aerobic benefits of exercise are produced by movements requiring dynamic and rhythmic use of large muscles for an extended period of time. This type of exercise is most effective when performed frequently, and at a moderate intensity relative to the individual's maximal capacity. The American College of Sports Medicine (ACSM) (1990) recommends that individuals exercise at 60-90% of maximum heart rate (HRmax) or 50-85% of maximum oxygen uptake

(VO_2max), for 20-60 minutes per session to improve cardiovascular endurance. Any activity that uses large muscle groups, can be maintained continuously, and is rhythmical in nature, is a suitable aerobic exercise.

Walking, once belittled by runners and other athletes, is gaining prominence as an excellent aerobic activity suitable for practically everyone. The low incidence of injury among walkers, along with its ability to provide an aerobic workout, makes this fitness option attractive to a significant number of people (Moore, 1989).

Energy expenditure for walking depends largely on the speed and weight of the walker (Schultz, 1980). Porcari, et al. (1987) found that for most adults, fast walking can provide an adequate aerobic stimulus. According to Stamford (1986), aerobic benefits can be obtained from walking at a speed of 3.5 to 4.5 mph. The author also adds that this speed may not provide sufficient stimulation once one reaches an initial level of fitness, a fact which would require an increase in the walking pace.

Stamford (1986) mentions several ways to increase the energy expenditure and overall long-term benefits of walking, including the use of hand or wrist weights, ankle weights, and weighted vests. Other ways which were determined to increase the intensity included walking up hills, alternating between walking and running, and racewalking.

In recent years, upper body exercise has been recommended by physicians and fitness instructors as a supplement to lower body exercise and as a practical aerobic exercise for elderly persons with limited mobility (Rogers, 1986). Upper body development, which has generally been neglected due to sedentary lifestyles, can be greatly increased. According to Franklin (1989), many recreational and occupational activities require sustained arm and upper torso movement to a greater extent than leg work. Therefore, Franklin concludes that it is important to encourage individuals to train the arms and upper torso, as well as the legs. Properly exercised legs and upper torso create a progressive improvement in physical and aerobic fitness levels.

According to the ASCM (1990), strength training of a moderate intensity is sufficient to develop and maintain fat-free weight (FFW) and should be an integral part of an adult fitness program. One set of 8-12 repetitions of 8 to 10 exercises that condition the major muscle groups, performed at least 2 days per week, is the recommended minimum.

Paralleling the growing interest in exercise has been the growth of the fitness equipment industry. According to Legwold (1985), overall fitness equipment sales in the United States in 1990 were over $2.5 billion. A new piece of exercise equipment that has recently become popular with walkers are Exerstriders (Tom Rutlin, Exerstrider Products Inc., Madison, WI, 1991). Exerstriders are ski poles fitted with specially designed blunt rubber tips and are used in a manner similar to cross-country ski poles. Given the Exerstrider's ability to add an upper body component to walking, one might presume that the individual can simultaneously build upper extremity muscular strength and endurance while gaining aerobic benefits. To date, very little research has been conducted investigating the benefits of Exerstriders (Babyak, VanHeest, & Rodgers, 1991; Robaidek, 1989).

Statement of the Problem

Increased efforts have been directed towards the study of physiological responses to dynamic tasks using upper body muscle groups (Sawka, 1989). Since many recreational and occupational activities require sustained arm and upper torso movement to a greater extent than leg work, it appears reasonable to encourage individuals to train the arms as well as the legs (Franklin, 1989). Exerstriding can be considered as an ideal exercise which utilizes both the arms and legs. There is a need to demonstrate that in addition to the many benefits associated with walking, one can also simultaneously build and maintain the essential strength and endurance in major muscle groups of the upper body.

Purpose of the Study

The purpose of the study was to determine the potential changes in upper body strength and endurance, as a result of a 12-week walking program with specially designed poles (Exerstriders) in sedentary, adult women.

Hypothesis

The following null hypotheses were tested in this study:

1. There will be no significant changes in upper body endurance as a result of participating in a 12-week walking program among Exerstriders (E), walkers (W), and controls (C).
2. There will be no significant changes in upper body strength, as measured by a triceps pushdown strength test, as a result of participating in a 12-week walking program among E, W, and C.
3. There will be no significant changes in upper body strength, as measured by a modified lateral pulldown strength test, as a result of participating in a 12-week walking program among E, W, and C.

Assumptions

The following assumptions were made concerning this study:

1. All subjects gave a maximal effort during the testing sessions.

2. The subjects did not engage in any additional exercise beyond that prescribed, and did not change their normal dietary intake during the 12-week training program.
3. The Biokinetic Swim Bench imitated the upper body movements created when walking with the Exerstriders, and was a representative measure of upper body endurance.
4. There were no mechanical changes in the Biokinetic Swim Bench.
5. The modified lateral pulldown and the triceps pushdown exercises imitated the upper body movements created when walking with the Exerstriders, and were a valid measure of upper body strength.

Delimitations

The delimitations of the study were as follows:

1. The subjects were healthy, nonsmoking, sedentary female volunteers between 20-49 years of age, from the La Crosse area.
2. Only biceps and triceps strength measurements were measured.
3. Upper body muscular endurance was measured using only the Biokinetic Swim Bench.
4. The upper body endurance measurements were performed at speed setting number 9 (on a scale of 0-9, where a lower setting produced a higher resistance) on the Biokinetic Swim Bench (Sharp, Troup, & Costill, 1982).

5. Subjects in the exercise groups were required to exercise 4 days per week, with 2 of those sessions under supervision.
6. The training program lasted 12-weeks (48 sessions).

Limitations

This study was limited by the following conditions:

1. All subjects were volunteers and were not randomly selected.
2. The subjects' diet, sleep, and extracurricular activities could not be controlled and may have influenced the outcome of the tests.
3. Individual characteristics, such as skill level and inherent motivation, may have influenced the test results.
4. The Biokinetic Swim Bench was not calibrated and recalibrated during the pre and posttest phases due to inadequate equipment for doing so.

Definition of Terms

For the purpose of this study, the following terms were defined:

Biokinetic Swim Bench - is a semiaccommodating resistance device that creates a constant amount of acceleration in proportion to the force applied by the user (Sharp, Troup, & Costill, 1982).

Exerstrider - is a ski pole equipped with a specially designed rubber tip.

Isokinetic Contraction - is performed against a resistance that moves at a preset, constant speed (Pipes, 1977).

Isotonic Contraction - is a dynamic contraction which occurs through a range of motion against resistance. The speed of the movement is not fixed (DiNubile, 1991).

Muscular Endurance - is the ability of a muscle or muscle group to sustain contractions of a given force over time (Wilmore & Costill, 1988).

Muscle Overload Principle - is the workload for a muscle or a muscle group that is greater than that to which the muscle is accustomed (Ariel, 1983).

Muscular Strength - is the maximum force or tension generated by a muscle or muscle group. This refers to the ability to generate force without relation to time and implies a peak force during a maximal voluntary contraction (DiNubile, 1991).

One Repetition Maximum (1-RM) - is the maximum amount of weight that can be lifted once during the performance of a standard weight-lifting exercise (Katch & Drumm, 1986).

Specificity Principle - relates to the nature of changes, structural and functional, systemic and local, that happen as a result of training (DiNubile, 1991).

Torque - is a measure of angular force in an isokinetic dynamometer and is expressed in foot-pounds (Bendle, 1985).

Total Work - is the total volume of work under the torque curve with each repetition. Total work can also be calculated for the entire duration of the test period (Bendle, 1985).

<u>Universal Gym "Centurion II"</u> - is a weight lifting system which offers the Dynamic Variable Resistance approach to conditioning ("A Look at Equipment," 1980).

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

This chapter reviews the literature related to the effect of training on muscular strength and endurance. This chapter is subdivided into the following sections: 1) Definitions of muscular strength and endurance and their relation to physical fitness, 2) Principles of training: Overload and specificity, 3) Training for muscular strength and endurance, 4) Measurement of muscular strength, 5) Measurement of muscular endurance, 6) The effect of light handweights on strength development when carried while walking or running, and 7) Muscular strength and aerobic exercise patterns.

Definition of Terms

Strength or resistance training has been in existence since the early 1940's (DiNubile, 1991) and has experienced a resurgence in popularity in the past decade. Previously it was used primarily by athletes to improve their strength and size, and by individuals working to develop their physique. Its role has expanded to routine use in a wide variety of circumstances, including injury rehabilitation and prevention, posture improvement, and general conditioning.

The ASCM (1991) has revised and updated its recommendations for exercise in healthy adults. According to the new guidelines, the term "physical fitness" is described as being "composed of a variety of characteristics included in the broad categories of cardiorespiratory fitness, body composition, muscular strength and endurance, and flexibility." (p. 35).

According to the aforementioned 1991 ACSM position statement, it is clear that the inclusion of strength training is believed to be one of the important components of a well rounded fitness program that exercises all the major muscle groups of the body. A similar position stated by Franklin, Bonzheim, Gordon, and Timmis (1991), is that mild to moderate resistance training can be effective in improving muscular strength in cardiac patients.

Muscular Strength

Heusner (1980) refers to strength as the "effective biomechanical force that results from one maximal voluntary contraction of a muscle or group of muscles." (p. 145). Heusner further elaborates on the above statement as follows: (1) The effective force output of the musculoskeletal system is strength. (2) Strength is defined in terms of "maximum voluntary force which is dependent upon the subjects' current state of motor learning and degree of central nervous system inhibition." (p. 145). Only some fraction of one's latent muscular force, will be released at any given level of training. Additional strength gains will depend upon neural and musculoskeletal adaptations.

(3) Strength is measured in terms of a "simple maximal contraction, and any more than one contraction immediately introduces a component of muscular endurance." (p. 145). According to Huesner (1980) and the ACSM guidelines (ACSM, 1991), typical units of strength or force are the pound (lb) in the imperial system and the Newton (N) in the metric system.

Muscular Endurance

Muscular endurance is defined as the ability of a muscle group to execute repeated contractions (i.e., perform work) over a period of time (ACSM, 1991). Huesner (1980) defines muscular endurance as the "length of time or the number of repetitions that a muscular contraction can be performed." (p. 146). He further elaborates that "an equivalent way of describing muscular endurance is to say that it is the duration of time a person can continue to do a specific amount of work with a given muscle or muscle group." (p. 146). Wilmore and Costill (1988) define muscular endurance as the ability of a muscle or muscle group to sustain contractions of a given force over time. This, according to the authors, is related to the fiber-type of an individual's muscles.

According to Heusner (1980), muscular endurance is physiologically distinct from cardiovascular endurance.

Hickson, Rosenkoetter, and Brown (1980) state that muscular endurance can be improved as a separate entity without the changes occurring that usually denote increased cardiovascular endurance.

Principles of Training

The concepts of overload and specificity are basic to any training, exercise, or rehabilitation program. This is certainly true of strength training (DiNubile, 1991). DiNubile states that overload and specificity relate to an organ's ability to adapt to imposed stress, and include both structural and functional changes. Without adherence to these principles, gains cannot be expected.

Overload

According to DiNubile (1991), overload occurs when an individual physically demands more of his or her muscles than is normally required or utilized. The amounts and nature of overload will obviously vary greatly, depending on the individual's activity and level of muscular development. According to deVries (1986), resistance greater than the optimal load for a given individual constitutes an overload. To effect gains in muscle size or strength, the muscular system involved must be progressively overworked. In strength training, this is usually accomplished by increasing the resistance or weight, the number of repetitions, or the overall intensity of the activity. This is not a static situation and as gains are made, adjustments must be made or the individual will become accommodated to a given load. Although the achieved level of strength may be maintained, progress will cease (DiNubile, 1991).

Specificity

Specificity relates to the nature of changes, structural and functional, systemic and local, that occur in an individual as a result of training (DiNubile, 1991). These adaptations are extremely specific and quite predictable and they will occur only in the area stimulated with overload. The author further states that the Specific Adaptation to Imposed Demands (SAID) principle is the basis for program design and is better understood when comparing training programs of different types of athletes and their effects. An example is given by the author when comparing a distance runner and a powerlifter, both of whom choose to train only in their given activity. The runner will experience improved cardiovascular ability and development of muscular endurance in the major working muscles of the lower extremities. This improvement will not be maximally demonstrated if tested with a swimming test or rowing ergometer. A running test is required. If the runner's muscular endurance is measured by a swimming or rowing ergometer test, one would probably not see improvements as the muscles which were trained were not used in the testing.

When applied to strength training, the concept of specificity has other implications. Specific movement patterns are required by different sports, and programs should be designed accordingly. In addition to utilizing all major muscle groups, a good overall program should also be modified for the athletes' sport demands. For instance, a baseball pitcher needs more attention paid to the rotator cuff, shoulder girdle, and upper extremities in comparison to a soccer player whose lower extremity program should include strength and endurance work, as well as proprioceptive training.

Training for Muscular Strength and Endurance

In ancient Greece, Milo, the Olympic wrestler, lifted a calf each day until it reached full growth (DiNubile, 1991). This early form of strength training used the "progressive resistance exercise " (PRE) principle. The first systematic approach to progressive strength training was introduced by DeLorme (1945) and DeLorme and Watkins (1948). They used a system of cables and pulleys and gradually increased the amount of resistance. The amount of resistance was based on the weight which could be moved through the range of motion, not to exceed 10 consecutive repetitions.

The theory, known as the DeLorme Axiom, maintains that high-resistance, low-repetition (HR-LR) exercises develop strong muscles, whereas low-resistance, high-repetition (LR-HR) exercises enhance muscular endurance (DeLorme, 1945). Anderson and Kearney's study (1982) found that subjects trained on a HR-LR program were significantly stronger than subjects trained on programs of medium resistance-medium repetition (MR-MR) and LR-HR. Results also revealed that the HR-LR trained group actually decreased in performance on a test of relative muscular endurance, whereas the MR-MR and LR-HR treated groups showed significant increases of 22 and 28%, respectively, on the same test. Anderson and Kearney (1982) concluded that human skeletal muscles make both general and specific adaptations to a training stimulus. To develop strength, a program of HR-LR is the most desirable. To develop muscular endurance, a program of LR-HR is preferable. These assumptions support both the concept of specificity of training for acquisition of strength and muscular endurance and the DeLorme axiom.

Measurement of Muscular Strength

Throughout the years, many methods have been used in order to measure muscular strength. There are a variety of available methods for attempting to measure strength, including tensiometry, dynamometry, one-repetition maximum (1-RM), and computer-assisted output determination (DiNubile, 1991; Pollock & Wilmore, 1990). Based on the equipment available for this study, 1-RM testing was used.

One Repetition Maximum (1-RM)

When sophisticated laboratory equipment is unavailable for assessing strength, having the individual lift as much as he or she can, just one time, provides a simple but accurate estimate of strength (Pollock & Wilmore, 1990).

This is referred to as the one-repetition maximum (1-RM). According to the authors, strength can be easily assessed by the 1-RM test. Berger (1982) also states that a common measure of absolute strength is the amount of weight lifted once (1-RM), using barbells or a Universal Gym. In describing the 1-RM test, Pollock and Wilmore state that the basic muscle group to be tested is selected, then the individual is given a series of trials to determine the greatest weight that can be lifted. The principle according to which this test is conducted is trial and error, where the subject starts with a weight that can be lifted comfortably, then weight is added progressively until the weight can be lifted correctly only once.

In a study conducted by Berger (1962), he describes the 1-RM test. The maximum weight a subject could lift was determined by increasing the load by 10 pounds, until the subject failed. The load was then increased by 5 pounds until the maximum was obtained.

According to Berger, when strength is measured by an isometric contraction, a back and leg dynamometer or a tensiometer is frequently used.

Measurement of Muscular Endurance

Muscular endurance is usually measured by determining the number of repetitions of a given exercise (i.e., bench press, pull ups, and sit ups) that can be performed in a specific period or, alternatively, the number of continuous repetitions that can be done indefinitely to failure (DiNubile, 1991). According to the author, there are also fatigue tests that utilize the time of a sustained isometric contraction. According to Pollock and Wilmore (1990), a simple measure of muscular endurance involves determining the number of repetitions a person can complete while lifting a fixed percentage of his or her 1-RM. For example, the authors state if two individuals have an identical 1-RM bench press of 200 pounds, the one who performs more repetitions at 75% of that 1-RM (i.e., 150 pounds), would have the greater muscular endurance.

The Biokinetic Swim Bench

With the advent of isokinetic equipment, more accurate, reproducible methods are now available for measure of muscular endurance. Heusner (1980) defines muscular endurance in terms of the length of time or number of repetitions a given contraction can be performed. With specific reference to swimming, he describes muscular endurance as the ability to generate a required level of power for a prolonged period of time. Since swimming specialists strive for both the development and maintenance of power, the training routines suggested are power-oriented training. The concept of power-oriented training adds the idea of a specified duration to the former operational description of power training. That is, setting an approximate limb velocity or cadence which simulates the desired rate of motion in competitive situations. The athlete then applies as much force as possible at that velocity for a period of time which is roughly equivalent to the duration of a typical race. Additionally, the number of repetitions can be specified instead of a length of time. Ideally, concludes Heusner, the routine will be designed so that the athlete experiences localized muscular exhaustion at the end of each bout of exercise.

Counsilman (1979) describes an ideal form of exercise as one which would provide an accommodating resistance exercise in which a factor of acceleration is also present. The closer the pattern of acceleration approximates that of the movement for which the muscle is being conditioned, the greater the transfer of training effect will be. The exercise is called biokinetic exercise: "bio" meaning "life" and "kinetic" meaning "action". With this concept in mind, the Biokinetic Swim Bench was designed to fulfill the specifications that have been described above, and to duplicate as closely as possible the acceleration characteristics of swimming. The author further states that suitable exercise equipment provides accommodating resistance plus an acceleration pattern similar to that used in human motion. These characteristics would permit the maximum conditioning of both the slow twitch and fast twitch fibers in a single bout.

Counsilman describes the Biokinetic Swim Bench as using a shunted generator. The resistance is electromagnetic, not frictional, resulting in few, if any, breakdowns. The Biokinetic Swim Bench can be used at ten different speeds, the slowest being much slower than a swimmer would ever perform in the water and the fastest allowing him/her to move his/her arms much faster than when sprinting with an all out effort. It permits swimmers to pull their arms in the same pull pattern they would use when swimming various strokes, thereby providing maximum transfer of training effect.

The Biokinetic Swim Bench automatically accommodates to the resistance placed on it by the exerciser. If the athlete exerts as little as 5 or as much as 100 pounds, the Biokinetic Swim Bench will respond precisely to that amount of resistance. This eliminates the need for pin setting or concern for the amount of resistance to choose. Most importantly, the Biokinetic Swim Bench permits acceleration and allows the muscle fibers to be utilized in the sequence they will follow when a swimmer is performing his event. According to the author, the Biokinetic Swim Bench is equipped with an electronic readout that is accurate within plus or minus, one percent. It measures the work done by the athlete in kilopound meters (work equals force times distance) and the electronic readout indicates both force and distance.

Biokinetic Swim Bench testing protocols. In a preliminary evaluation of recently developed electronic readout systems in combination with various isokinetic exercise equipment, the work performance characteristics of 16 members of a swim team were measured and analyzed in dry-land exercise programs (Thornton & Flavell, 1977). The authors found good correlation between the data obtained in a prototype testing program and the performance of the swimmers in the water. The authors state that this equipment has only recently been developed and no standard testing protocol has yet evolved. The equipment used by the authors was the Isokinetic Swim Bench, which the swimmers had been using routinely in their dry-land exercise program.

The Isokinetic Swim Bench readout measures, computes, and displays the amount of work being done by the swimmer while using the machine. The information displayed on the readout is in kilopound meters (kpm) of work, which is the product of the force generated by the swimmer (1 kilopound = 2.2 pound) and the distance (in meters) through which he applies the force (1 kpm = 7.233 footpounds of work). The testing program on the Isokinetic Swim Bench consisted of 2 minute bouts of double-arm pulls at moderately high speed. The amount of work completed in each 6 second increment for a total of 20 readings was recorded. The swimmers were instructed to maximize the amount of work completed in 12 seconds, 30 seconds, 1 minute and 2 minutes. According to these instructions, it was possible to obtain data from which the researchers could plot the fatigue characteristics of each swimmer and compare them to the average curves for sprint and distance swimmers.

In a study which assessed the effectiveness of a high speed isokinetic strength training in improving the performance of competitive swimmers, Pipes (1978a) used a 2 minute work test. The test was given on the Isokinetic Swim Bench with an ergometer readout, where total work output in kilopound meters was recorded every 30 seconds. In another study, Pipes (1978b) investigated the number of repetitions required and the length of time most beneficial in isokinetic training for strength gains and improved athletic performance. The study also included a 2 minute work test which was given on the Isokinetic Swim Bench ergometer readout. Total work in kilopound meters was recorded for each 30 seconds of work, using the testing protocol of Thornton and Flavell (1977), done with the "Pacer 2" accumulative readout system.

Costill, Sharp, and Troup (1980) examined muscular strength and its contribution to sprint swimming. According to the authors, they felt that one of the prerequisites which was necessary for the study of the relationship between strength and swimming performance was that the tests for muscular strength must simulate the arm motion during swimming. The authors chose to use a Biokinetic Swim Bench.

Although the Biokinetic Swim Bench cannot fully duplicate the arm and hand actions executed in the water, it does allow one to incorporate, in one motion, most of the muscle groups and the mechanics required during sprint swimming. In addition, the authors stated that the Biokinetic Swim Bench is relatively inexpensive. In order to measure the speed of each arm pull, the authors first connected the Biokinetic Swim Bench to a recorder, so that they could determine the relationship between arm pull speed and force at each of the Biokinetic Swim Bench speed settings (0-9). It was then simple to convert the measurements of force to power (power = force x velocity). In an effort to assess the anaerobic factors which, in part, limit performance in events longer than 50 yards, the authors conducted an anaerobic fatigue test which involved a series of rapid, maximal pulls on the Biokinetic Swim Bench. The swimmers were then required to perform 40 maximal pulls as rapidly as possible at a velocity of 0.5 m/sec (setting #0). The amount of work performed after each five pulls and at the completion of all 40 pulls was recorded.

Gehlsen, Grigsby, and Winant (1984) quantified the effects of an aquatic exercise program on muscular strength, endurance, and power of patients with multiple sclerosis. Two types of isokinetic dynamometers were used to assess the muscular variables studied, one of which was the Biokinetic Swim Bench. It was used to measure muscular force, fatigue, and power in the upper extremities. After being familiarized with the use of the Biokinetic Swim Bench, subjects were allowed a warm-up of two practice pulls at each speed setting. Peak force measurements were obtained from the best of three trials at the speed settings of 0, 2, 4, and 6. After a 5 minute rest period, each subject performed a 45 second test to muscular fatigue. The total work and fatigue test was performed at the high tension speed setting of 0 (0.5 m/sec). The digital work integrator recorded the total work produced during the test. Fatigue was measured as the percentage of decline of peak force from the average of the first three and last three arm pulls. The subjects were instructed to give a maximum effort on every muscular contraction, and verbal encouragement was given during each test.

Total Work as a Measure of Muscular Endurance

Muscular endurance is the ability of the contracting muscles to perform repeated contractions against a load (Baltzopoulos & Brodie, 1989). Moffroid and Whipple (1970) used total work performed by the quadriceps muscle groups to assess muscular endurance. The authors determined the specific effects on muscular endurance and muscular force of two different training speeds. The two training programs administered to two different groups were slow maximal exercise (6 revolutions per minute) and rapid maximal exercise (18 revolutions per minute), for 2 minutes, three times a week for 6 weeks. The velocity of exercise was controlled by means of an isokinetic device. Increase in total work at each training speed was converted to an index of improvement in muscle endurance.

The work of every repetition in a 2 minute exercise period was calculated, added, and the sum was divided by the total number of seconds the muscle (quadriceps) was actually contracting. The authors called the resulting value "energy" (total work in a given period of time or average power) and it represented the operational definition of endurance in their study.

According to the authors, muscular endurance was defined as the average power output over a given period of time and could be quantified in units of Newton meters of work per second for 2 minutes. The authors found that the group training at a fast speed (18 revolutions per minute), showed greater improvements in muscular endurance than the slow group (6 revolutions per minute).

Adeyanju, Crews, and Meadors (1983) determined the effects of two speeds of isokinetic training on muscular strength, power, and endurance. Thirty college females were assigned to a fast speed experimental group which trained at a speed of 180 deg/sec and a slow speed experimental group which trained at 30 deg/sec. Each of the experimental groups performed a program of knee flexion and extension on the isokinetic Orthroton. Each subject performed three sets

(20 seconds in duration, with 30 seconds of rest between sets) of repetitions per training session, with a training frequency of 3 days per week, for 7 weeks. Muscular endurance was defined to be the number of repetitions performed before the maximum torque was decreased by 50% of the initial value. The authors found significant improvements in muscular endurance in both the quadriceps and the hamstring muscle groups in the two training groups.

A study by Bendle (1985) provided a comprehensive investigation into the effect that repetitions have on isokinetic strength and muscular power and endurance. Muscular endurance was assessed by using an isokinetic dynamometer to calculate the total work performed by the muscle group during a predetermined repetition bout endurance test. The study determined the optimal number of repetitions necessary to obtain maximal effectiveness for isokinetic training. Sixteen male and 23 female students were assigned to training groups of varying repetitions. All subjects had their knee flexors and extensors pre and posttested on a Cybex II Isokinetic Dynamometer before and after training. Experimental subjects trained three times per week for 6 weeks at 180 deg/sec. The groups of 3 X 10 reps, 3 X 15 reps, and 3 X 20 reps, showed significant improvement in the total work in the quadriceps muscle, whereas for the hamstring, the group of 3 X 10 reps was the only group to increase their total work significantly. A 30 repetition muscular endurance test at 180 deg/sec was used to measure total work.

Carr, Conlee, and Fisher (1981) compared the effects of fast and slow speed isokinetic training on strength, endurance, and muscle fiber composition. The authors trained 10 subjects with one leg using slow contractions (48 deg/sec) and the other using fast contractions (192 deg/sec), 3 days per week for 9 weeks. Each leg's total work was the same. A 2 minute endurance test at both the fast and slow training speeds was performed. Muscular endurance improved at both the fast and slow contraction speeds in both legs. A tendency for greater muscular endurance at the end of the fast speed endurance test was demonstrated by legs which were trained with fast contractions. The authors suggested that gains in muscular endurance were related to the total work performed.

A study by Burdett and Van Swearingen (1987) determined the reliability of several methods assessing muscular endurance of the quadriceps and hamstring muscle groups, using a clinical protocol recommended for use on the Cybex II isokinetic dynamometer. Among the parameters tested were total work measurements. Thirty-six healthy young adults with no history of chronic or present knee pathology participated. The Cybex II was programmed to collect torque data on 25 consecutive quadriceps and hamstrings contractions at a predetermined speed (either 180 or 240 deg/sec) and then to print the total work during all 25 contractions. The subject was instructed to push and pull through the full available range of motion as fast and as hard as possible until notified by the tester to stop. The test was terminated upon completion of 25 contractions or the decline of the quadriceps torque to 50% of the initial maximum value. Testing occurred on 4 occasions for each subject, using this protocol (twice at 180 deg/sec and twice at 240 deg/sec), with a minimum of a 2-day rest between testing sessions. Test-retest reliabilities were calculated for the test of total work of all 25 contractions at both speeds for the quadriceps in consecutive sessions. Reliabilities for measuring total work for all 25 contractions from the data produced by the hamstring were also calculated. Total work of all 25 contractions appeared to be very reliably measured at both speeds of contraction for the quadriceps ($r = .98$ and $r = .87$ for the speeds of 180 deg/sec and 240 deg/sec, respectively). The reliability of measuring this parameter for the hamstrings was not as high ($r = .91$ and $r = .83$, for the speeds 180 deg/sec and 240 deg/sec, respectively), but still generally above the level of .80 needed for a clinically reliable test (Currier, 1984). The study results suggest that total work done during all 25 contractions was one of the most reliable tests for assessing muscular endurance.

The Effect of Light Handweights on the Development of Muscular Strength and Endurance

Carrying light handweights while exercising has become a popular training mode for many people (Mirkin, 1983; Schwartz, 1982, 1987; Stamford, 1984). Handweights have been added to popular aerobic regimens such as walking, jogging, and aerobic dance (Auble & Schwartz, 1991).

According to Schwartz (1982, 1987), the fact that the light handweights are popular and used in conjunction with running is due to a presumed relationship between endurance and strength. There have been a few studies which looked at a proposed benefit of running with light handweights and weighted gloves to help increase upper extremity muscular strength and power (Ewing, Vandeputte, & Francis, 1987; Hoke & Ostrom, 1983).

According to Hoke and Ostrom (1983), weighted gloves have been introduced to long distance runners as a training mode for increasing arm and wrist strength. The authors tested 14 distance runners, before and after a 2 month training study. The experimental group ran through normal training wearing a 1 pound glove on each hand, while the control group did not vary from their normal routine. The authors used an isokinetic dynamometer equipped with a dual channel recorder to monitor possible strength changes in the wrist flexors and extensors, elbow flexors and extensors, and shoulder flexors, extensors, abductors, and adductors.

The experimental group did not show significant increases in any of the muscle groups tested at a speed of 60 deg/sec. At 180 deg/sec, the experimental group showed significantly greater changes in muscular strength of the elbow flexors and shoulder extensors. At 300 deg/sec, the elbow flexors and extensors of the experimental group showed significantly greater strength changes. The authors concluded that muscular strength was increased as a result of using weighted gloves during long distance running, but only at high speeds.

Ewing, et al. (1987) quantified strength changes as reflected in peak torque changes of the elbow and shoulder flexor and extensor muscles resulting from 8 weeks of running while carrying light handweights. Twenty male runners trained at the same training routine they reported prior to the initiation of the study. The experimental group ran with increasing loads of the light handweights during the study. They carried 0.45 kg in each hand for weeks 1 and 2, 0.91 kg in each hand for weeks 3 through 5 and 1.36 kg in each hand for weeks 6 through 8. Peak torque was measured using an isokinetic dynamometer. The results indicated no significant changes in any of the parameters tested at any of the time periods. The authors concluded from the results that using handweights while running did not provide a sufficient stimulus for inducing significant strength changes.

Muscular Strength and Aerobic Exercise Patterns

White, et al. (1984) examined the physiological adaptations to a 6 month aerobic dancing program and compared those responses to a similar group of women engaged in a walking program. The subjects were Caucasian female volunteers ranging in age from 50-63 years. The conditioning program for the dancing group consisted of performing five aerobic dances, 4 days per week, while the walking group walked 2 miles per day, four times per week. One purpose of the study was to evaluate the effectiveness of the two forms of aerobic training in improving muscular strength. The study strength measurements included elbow flexion, knee extension, and ankle plantar flexion. A cable tensiometer was used to evaluate muscular strength changes. Two maximum contractions for each muscle group were performed and averaged. Nondominant elbow flexion strength was measured with the subject lying supine and the arm flexed at an angle of 115 degrees. Isometric strength in right knee extension was measured with the subject seated and the knee flexed to an angle of 115 degrees. Right ankle plantar flexion was measured with the subject supine and the ankle flexed at a 90 degree angle. Results indicated that significant increases occurred in both knee extension and ankle plantar flexion strength for both groups. According to the authors, specificity of training was reflected in the ankle plantar flexion results, where the walkers improved to a much greater degree than the dancers (18.2% or 10.7 kg in the walkers in comparison to 5.2% or 3.8 kg in the dancers). On the other hand, the dancers showed nonsignificant improvement in elbow flexion strength when compared to the walkers (5% vs. 2%).

Summary

The definitions of both muscular strength and endurance have evolved over the past 50 years. As they are currently understood, muscular strength is the maximum force or tension generated by a muscle or muscle group, while muscular endurance is the ability of a muscle or muscle group to sustain contractions of a given force or time. In 1991, for the first time, the ACSM included both muscular strength and muscular endurance as important components of physical fitness.

As a principle of training, overload occurs when an individual physically demands more of his or her muscles than is normally required. Specificity relates to the nature of structural, functional, systemic, and local changes that occur in an individual as a result of training. These changes are extremely specific and predictable and will occur only in an area stimulated by overload.

With regard to training for muscle strength and endurance, the first systematic approach to progressive strength training was introduced by DeLorme. The DeLorme Theory of muscular strength development maintains that high resistance, low repetition (HR-LR) exercises develop muscular strength, while low-resistance, high-repetition (LR-HR) exercises enhance muscular endurance.

In the absence of sophisticated laboratory equipment, a 1-RM provides a simple, but accurate estimate of muscular strength. Muscular endurance is usually measured by determining the number of repetitions of a given exercise that can be performed in a specific period, or alternatively, the number of continuous repetitions that can be done indefinitely. The Biokinetic Swim Bench provides a measurement of upper extremity muscular force, fatigue, and power. The ability of an isokinetic dynamometer to measure total work (which can be reliably converted to an index of muscle endurance) over a given time, enables one to observe a muscle's ability to sustain contractions. Protocols for the measurement of muscle endurance in swimmers engaged in dry-land exercises have been developed with the help of the Biokinetic Swim Bench.

The current popularity of handweights used in conjunction with running is due to a presumed relationship between endurance and strength. Of the two studies utilizing handweights or weighted gloves reviewed in this section, only one demonstrated significant changes in muscular strength, but only at a certain speed; whereas muscular endurance has not been measured in either study.

Given the importance of both muscular strength and muscular endurance for physical fitness, further studies examining aerobic exercise patterns and designed to measure both of these variables are warranted.

CHAPTER III

METHODS AND PROCEDURES

Introduction

The purpose of this study was to determine whether there was a significant increase in upper body muscular strength and endurance as a result of a 12-week walking program using specially designed poles (Exerstriders) in sedentary women. This study was designed as part of a larger comprehensive study which sought to determine what, if any, differences occurred in aerobic capacity, body composition, and personal well being, as a result of the training program.

This chapter is divided into the following sections: subject selection, development of instrumentation, experimental procedures, and statistical treatment of the data.

Subject Selection

Ninety-nine inactive women between 20-49 years of age from the La Crosse area volunteered to participate in the study. The subjects were recruited through an article in the local newspaper as well as an advertisement in the Lutheran Hospital newsletter (see Appendix A). Flyers were also distributed and posted on the University of Wisconsin-La Crosse campus and several central points in the city of

La Crosse. As potential subjects called in, they were interviewed on the phone and answered a preliminary questionnaire, designed specifically for this study (see Appendix B). Once they satisfied the set requirements, as detailed below, they were accepted on a first-come, first-served basis.

All subjects were required to be healthy, medication-free and nonsmoking. No limiting physical or orthopedic conditions which would preclude their participation in the tests were allowed. The subjects were allowed to have only one major risk factor from the following: 1) diagnosed hypertension or systolic blood pressure > 160 or diastolic blood pressure > 90 mm Hg on at least 2 separate occasions, or on antihypertensive medication, 2) serum cholesterol > 6.20 mmol/L (>240 mg/dl), 3) cigarette smoking, 4) diabetes mellitus, or 5) family history of coronary or other atherosclerotic disease in parents or siblings prior to age 55. The subjects agreed not to engage in any additional exercise beyond that prescribed and also agreed not to change their diet. Prior to their introductory practice session, each subject signed a document (see Appendix C), which further described the tests and potential risks involved.

The subjects were randomly assigned to one of three groups: 1) Exerstrider (E) group (n = 35), 2) Walking (W) group (n = 35), or 3) Control (C) group (n = 29). The three study groups were determined after all subjects had completed their pre-study tests.

Instrumentation

Upper Body Muscular Endurance

Recent developments in strength testing equipment have provided the opportunity of evaluating strength in a manner that closely mimics the desired movement. In this study, upper body (arm and shoulder) muscular endurance was measured with a Biokinetic Swim Bench (see Figure 1). The Biokinetic Swim Bench is a semiaccommodating resistance device that creates a constant amount of acceleration in proportion to the force applied by the user. The amount of work which is done by the subject is measured with the digital work integrator supplied with the bench. The information is given in kilopound meter (kpm) of work, the product of the force generated by the subject (1 kilopound = 2.2 lb) and the distance (in meters) through which the subject applied the force (Thornton & Flavell, 1977). The relationship between upper body power capacity on the Biokinetic Swim Bench and swimming performance has been documented on several occasions (Costill, King, Holdren, & Hargreaves, 1983; Sharp, 1986; Sharp, Troup, & Costill, 1982; Thornton & Flavell, 1977).

Figure 1. Biokinetic Swim Bench.

Upper Body Muscular Strength

Strength was determined using a Universal Gym apparatus (see Figure 2). One-repetition maximum (1-RM) tests were performed for the triceps pushdown and modified (palms up) lateral pulldown exercises.

Experimental Procedures

The subjects took part in both practice and testing sessions. The procedures for both sessions are explained below.

Practice Session

After potential subjects had been interviewed on the phone, and were found to satisfy the study requirements, they were assigned a time for an introductory practice session. Initially, at the practice session, the subject completed a personal profile inventory and then read and signed an informed consent form (see Appendix C), which explained the procedures and possible risks involved with the testing. After all questions were answered, subjects were oriented to the treadmill testing, the underwater weighing, and the muscular endurance and strength tests, in that order.

For the muscular endurance testing the subject was instructed in the operation of the Biokinetic Swim Bench and given the opportunity to perform alternating arm pulls with the speed selector set at 9 (3 m/sec) until she felt

Figure 2. Universal Gym.

comfortable with the device. Afterwards, the subject was oriented to the Universal Gym apparatus and instructed how to perform the triceps pushdown and the modified lateral pulldown. Both exercises were practiced at the minimum weight setting.

Testing Procedures for Upper Body Muscular Endurance

Upper body muscular endurance testing was done in the Human Performance Laboratory at the University of Wisconsin, La Crosse (UW-L). Before the testing began, the subject was instructed to perform several warm-up exercises to stretch the arm and shoulder muscles. The subject was then told to stand facing the Biokinetic Swim Bench, placing feet and toes on a line, clearly marked on the floor, approximately 36 inches from the Biokinetic Swim Bench, and instructed to put her hands through the straps and grip the cable handgrip. The subject was then instructed to move her arms back and forth in a flowing movement, exerting maximal effort with every pull. She was also instructed to breathe normally, exhaling while pulling. The subject was told not to rotate the upper body excessively, nor to swing her palms too high, and to keep her back straight. The subject was then told that in order to perform a complete movement of the arms, which would duplicate a workout utilizing the Exerstriders, she must pull backwards until the marks on the bench cables were clearly visible above the pulley.

With the speed selector on the Biokinetic Swim Bench set at 9 (3 m/sec), the subject was asked to pull alternately with both arms for 1 minute (see Figure 3). After completing the test, the subject was asked to stretch her upper body for 2 to 3 minutes and advised that any soreness or stiffness she may have felt would probably disappear within a short time.

Testing Procedures for Muscular Strength

Strength was measured for triceps pushdown and the modified lateral pulldown exercises. A 1-RM strength test was used for both exercises. After a brief warm up, consisting of stretching and lifting five repetitions at a minimal weight load, the strength assessment on each of the two exercises was achieved by gradually increasing the amount of weight that could be lifted at one time. Two and one-half-pound weight increments were used in order to determine the accurate amount of weight which could be successfully lifted. Upon completion of the workout, the subject did several arm and shoulder stretching movements for her cooldown.

Triceps pushdown. The triceps pushdown was performed by each subject with feet planted on the ground, shoulder-width apart. Using the overhead grip, maintaining a

Figure 3. Upper body muscular endurance testing.

straight back and with elbows at her sides, the subject began to push down vertically until her arms were at a point parallel to the floor. The subject then pushed down again until her arms were fully extended and then returned to the starting position (see Figures 4-5).

Modified lateral pulldown. The modified lateral pulldown was performed by each subject while sitting on a bench, facing the Universal Gym, with the feet flat on the floor. Using a palms-up grip and hands shoulder width apart, the subject pulled vertically downward, below the level of her chin. The subject was instructed to avoid backward lean, and the elbows were to be kept at her sides. The subject then extended her arms and returned to the starting position (see Figures 6-7).

Training Program

After the prestudy tests were completed, the subjects in the two exercise groups began a 12-week training program. Subjects were required to exercise 4 days per week, 2 of which were to be completed during supervised periods, for a total of 48 sessions. Supervised sessions took place at the UW-L outdoor track or the indoor track during inclement weather. Training sessions held outside the UW-L facilities had to be performed on level terrain. All participants maintained a weekly exercise log, which documented their training frequency, intensity, and duration (see Appendix D).

Figure 4. Triceps pushdown - starting position.

Figure 5. Triceps pushdown - end position.

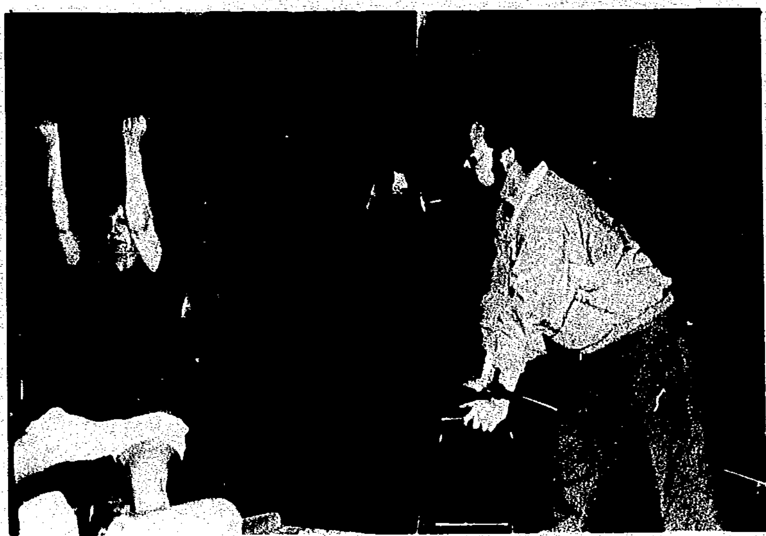


Figure 6. Modified lateral pulldown - starting position.

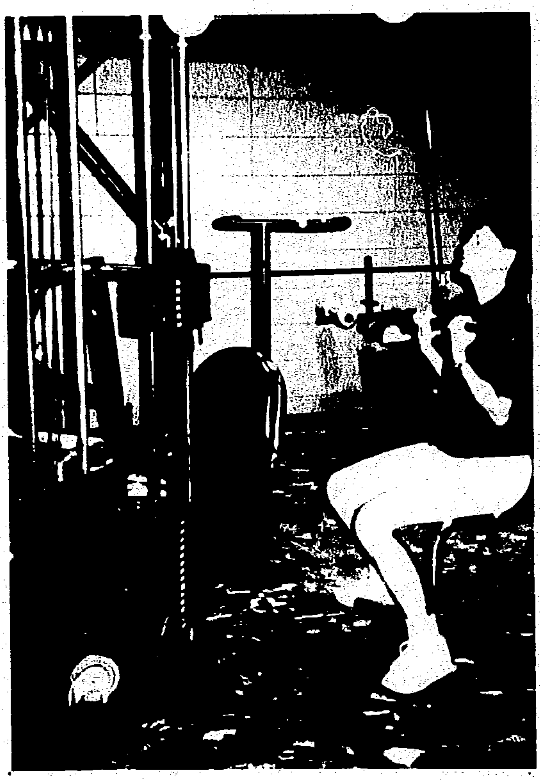


Figure 7. Modified lateral pulldown - end position.

The logs were collected and analyzed at the end of each week.

Both training groups (walkers and Exerstriders) were required to train the same number of days per week, at the same intensity and duration. The prescribed intensity ranged from 70-85% of the subjects' maximal heart rate, as determined from the results of the maximal treadmill test during the pretesting. In addition to the prescribed heart rate, a rating of perceived exertion between 12 and 15 on the Borg scale (ACSM, 1991) was to be used.

The duration of the exercise sessions was gradually increased from 20-25 minutes per session during the first week to 40-45 minutes per session by the fifth week, and stayed at 40-45 minutes throughout the remainder of the study (see Appendix E). Exercise duration remained at this level for the balance of the 12-week period. Both exercise groups received specific instructions for determining and monitoring their exercise heart rate. The Exerstrider group was also instructed in the use of their walking poles during the first week's introductory training sessions. Training group subjects were instructed to maintain their normal diet throughout the 12-week study period and not to engage in any additional exercise beyond that prescribed.

Members of the control group were instructed not to engage in any additional exercise beyond what they had already been doing on a regular basis during the month prior to the beginning of the study. They were also asked not to alter their diets nor change their life styles for the 12-week study period.

Statistical Analysis

Descriptive statistics (means and standard deviations) were calculated for age, height, weight, and percentage of body fat. Descriptive statistics were also calculated for training time, walking distance, walking speed, percentage HRmax, and RPE for each week of the 12-week training program for the Exerstrider and walking groups.

Within group differences from pre to posttesting for strength and endurance were analyzed with paired t-tests. Differences in change between groups for strength and endurance were analyzed with a one-way analysis of variance with repeated measures (REANOVA). If a significant F-ratio was obtained, a Tukey's post-hoc analysis was used to determine which pairs of means were significantly different. All of the data were measured for statistical significance at the $p<.01$ level.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

This project was designed as part of a larger study which also investigated changes in aerobic capacity, body composition, and general well being, which could be obtained when walking with Exerstriders. The purpose of this study was to determine the potential changes in upper body (arm and shoulder) muscular strength and endurance, as a result of participating in a 12-week walking program, with or without Exerstriders, in adult women. Upper body muscular strength was assessed using 1-RM tests for triceps pushdowns and a modified (palms up) lateral pulldown exercise. Upper body muscular endurance was determined by performing a 1 minute bout of alternating arm pulls on a modified Biokinetic Swim Bench apparatus. The total work output (kpm) was used as the criterion measure. The statistical analysis assessed whether or not there were significant differences between the study groups, and if there were any significant improvements from pre to posttesting within groups.

Subject Characteristics

Ninety-nine inactive women between 20-49 years of e from the La Crosse area were initially included in this study. Ninety-two subjects completed all testing sessions. Of the seven participants who dropped out, two had medical problems during the training period, two could not meet the training schedule, and three participants failed to complete the posttesting procedures. The descriptive statistics of the subjects who completed the testing are presented in Table 1.

Table 1. Descriptive statistics of the subjects (N = 92)

Group	n	Age (yrs)	Height (in)	Weight (lb)	Body Fat (%)
C	28	34.7±6.97	64.5±2.5	147.6±31.67	31.9±7.41
W	32	38.0±5.36	65.0±2.3	152.1±23.73	33.5±5.93
E	32	39.0±6.08	64.8±2.25	156.0±26.74	34.8±7.93

Note: All values represent mean ± standard deviation.

Training Program

Subjects in the E and W groups exercised for 4 days per week for 12 weeks. Two of the sessions were supervised and the remaining two sessions participants exercised on their own. An independent paired t-test was used to determine any statistically significant differences in the training program between the two experimental groups. The variables analyzed were time, distance, speed, intensity, and RPE for each week of the study. A .01 level of confidence was used as the critical statistical value to achieve statistical significance between the two groups. These comparisons are presented in Table 2.

There were isolated significant ($p<.01$) differences in the average amount of time spent per exercise session each week, the average distance per session, the average exercising speed per session, and the average RPE per session. The mean amounts of exercise time for group E in weeks 7, 8, and 9 were 42.6, 42.6, and 42.3 minutes per workout. The same measures for group W were 43.8, 43.9, and 43.7 minutes, respectively. The mean daily mileage of group E in weeks 6, 7, 8, and 10 was 2.7, 2.6, 2.6, and 2.7 miles, respectively. The same measures for group W were 3.0, 2.9, 2.9, and 3.0 miles, respectively. The average daily exercising speed of group E in weeks 6, 9 and 10 was 3.6, 3.8, and 3.8 mph per workout, while the same measure for group W was 4.1, 4.1, and 4.1 mph, respectively. The mean RPE of group E in week 8 was 14.2, and the same measure for group W was 13.5.

<u>Results of Muscular Strength and Endurance Testing</u>

One-way analysis of variance with repeated measures (REANOVA) was used to determine if there were significant changes in muscular strength and endurance among the three study groups as a consequence of participating in the study. If a significant F-ratio was obtained, a Tukey's post-hoc analysis was used to determine which pairs of means were significantly different. Within group differences from pre to posttesting were assessed using paired t-tests.

Table 2. Summary of the training program

Week	Time (sec)		Distance (miles)		Speed (mph)		Intensity (% HRmax)		RPE	
	W	E	W	E	W	E	W	E	W	E
1	24.1	23.2	1.3	1.3	3.0	3.2	73.3	74.5	12.8	12.7
2	28.5	28.5	1.8	1.8	3.7	3.7	76.6	76.3	13.1	13.1
3	33.0	33.8	2.1	2.0	3.9	3.5	77.3	76.7	13.2	13.3
4	38.7	38.3	2.4	2.3	3.8	3.8	77.1	78.5	13.2	13.5
5	42.7	42.8	2.7	2.6	3.8	3.6	77.5	77.2	13.5	13.9
6	43.5	43.1	3.0	2.7*	4.1	3.6*	77.7	77.3	13.6	13.9
7	43.8	42.6*	2.9	2.6*	4.0	3.7	78.8	78.0	14.1	14.3
8	43.9	42.6*	2.9	2.6*	4.0	3.7	77.6	76.5	13.5	14.2*
9	43.7	42.3*	3.0	2.8	4.1	3.8*	77.9	76.6	13.8	14.0
10	42.8	42.4	3.0	2.7*	4.1	3.8*	78.1	76.2	13.6	13.8
11	43.2	43.1	3.1	2.8	4.2	3.9	77.4	75.4	13.6	13.9
12	42.9	42.9	3.1	2.9	4.2	4.0	76.8	75.9	13.6	13.8
Mean	39.2	38.8	2.6	2.4	3.9	3.7	77.2	76.6	13.5	13.7

* Significant difference (p<.01) between groups.

Muscular Endurance Testing

Muscular endurance was assessed by calculating cumulative total work performed by the subjects during a minute bout of alternating arm pulls on a modified Biokinetic Swim Bench apparatus. Measurements were taken at 5, 10, 20, 30, 40, 50, and 60 seconds. The total work (kpm) in 1 minute for each group is presented in Table 3 and the cumulative data for each group are plotted in Figures 8-10.

There was a significant ($p<.01$) pre to posttesting increase in cumulative total work for the E group. This was demonstrated at all points of measurement as evidenced in Figure 9. The W group did not show a significant ($p>.01$) increase in total work, but did show a significant ($p<.01$) increase at 5 seconds. The C group did not have a significant ($p>.01$) increase in total work; however, it did show significant ($p<.01$) increases at 5, 10, and 20 seconds. The amount of change in total work for the E group was significantly ($p<.01$) greater than for the W or C groups, which did not differ from each other.

Muscular Strength Testing

Two upper body strength tests were administered to each subject. Strength (lb) was assessed using 1-RM tests for triceps pushdowns and a modified (palms up) lateral pulldown exercise. The two tests were performed on the Universal Gym apparatus.

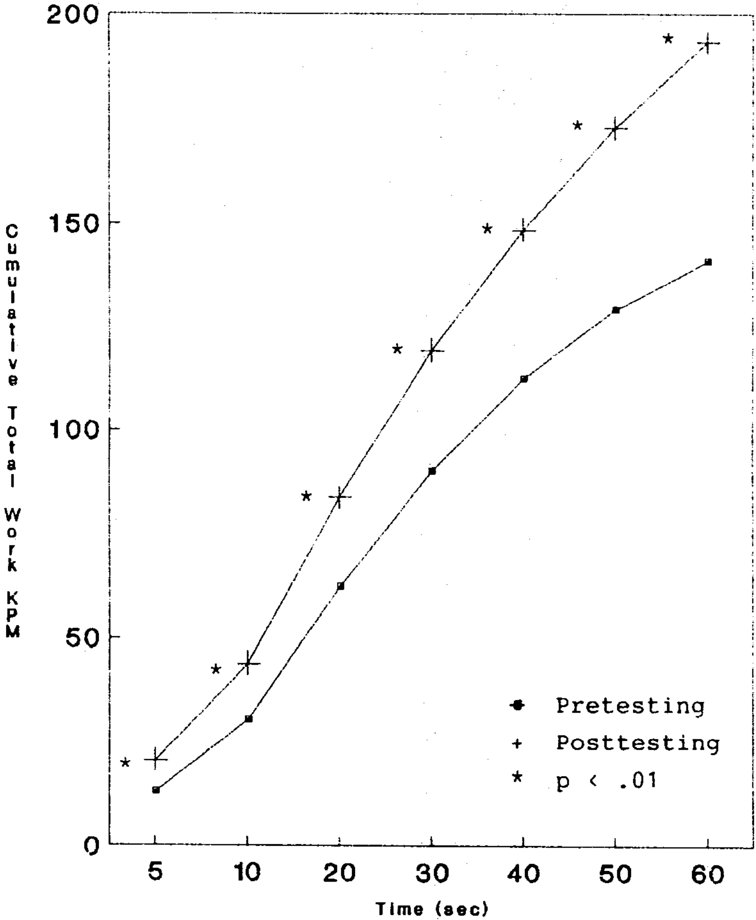


Figure 8. Comparison of pre to posttesting total work curves on the Biokinetic Swim Bench for Exerstriders (E).

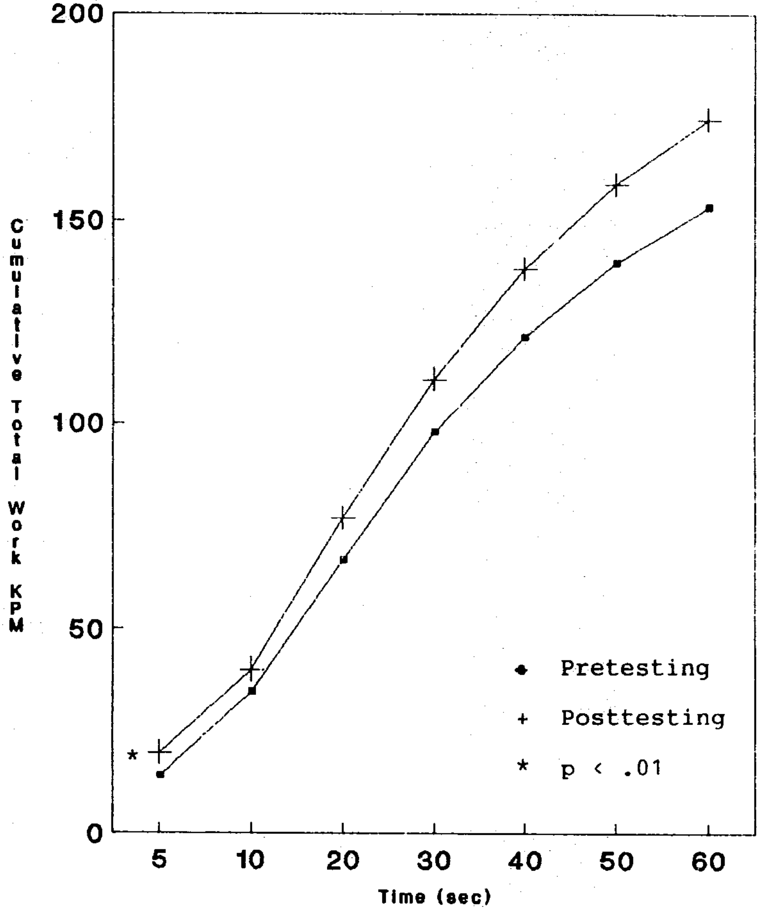
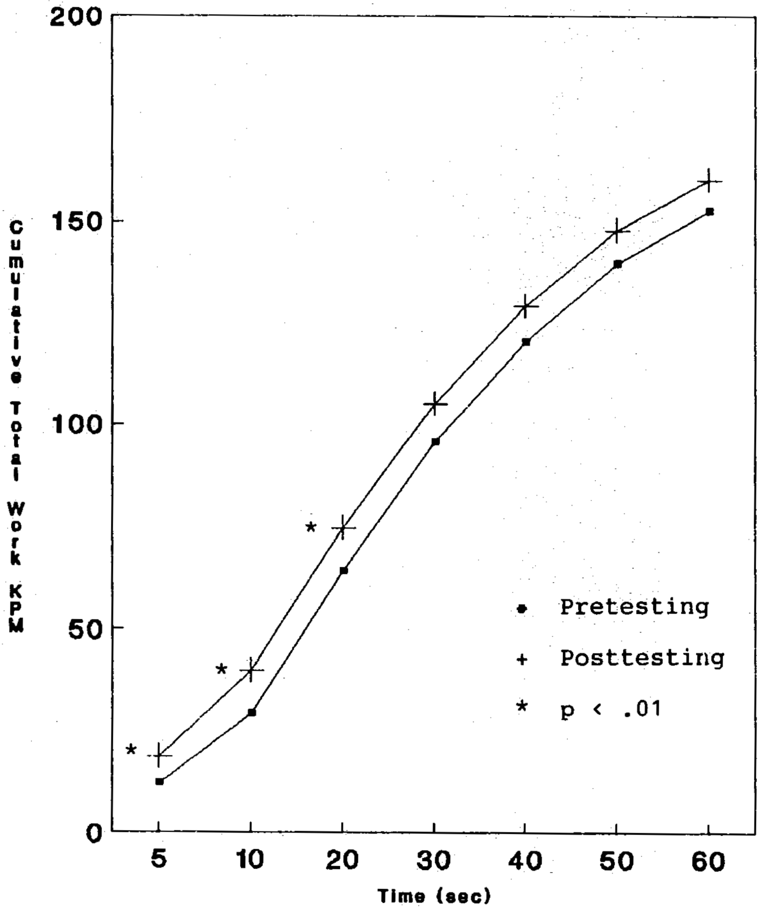


Figure 9. Comparison of pre to posttesting total work curves on the Biokinetic Swim Bench for Walkers (W).



<u>Figure 10</u>. Comparison of pre to posttesting total work curves on the Biokinetic Swim Bench for Controls (C).

Table 3. Total work (kpm) measurements from the upper body muscular endurance test (N = 92)

Group	n	Pretesting ($\overline{X}$±SD)	Posttesting ($\overline{X}$±SD)	Change (%)
C	21	152.3±51.67	160.0±49.69	7.7 (5%)
W	28	153.2±57.22	174.6±65.46	21.4 (14%)
E	32	140.8±44.46	193.1±70.15 *	52.3 (37%)+

* Significant difference ($p<.01$) from pre to posttesting.

+ A more significant change ($p<.01$) than Group W or C.

Table 4 presents a comparison of pre and posttesting means for the triceps pushdown test and Table 5 presents a comparison of pre and posttesting means for the modified lateral pulldown test. There were no significant ($p>.01$) differences within group or among group changes in strength for either exercise.

Table 4. A comparison of pre and posttesting means for the triceps pushdown strength test (lbs).

Group	n	Pretesting ($\overline{X}$±SD)	Posttesting ($\overline{X}$±SD)	Change (%)
C	28	38.8±6.33	38.3±5.58	-0.5 (.01%)
W	32	40.5±6.30	40.2±6.24	-0.3 (.01%)
E	32	39.1±7.29	40.2±7.04	1.1 (.03%)

Table 5. A comparison of pre and posttesting means for the modified lateral pulldown strength test (lbs).

Group	n	Pretesting ($\bar{x}$±SD)	Posttesting ($\bar{x}$±SD)	Changes (%)
C	28	69.5±15.95	72.2±15.28	2.7 (.04%)
W	32	75.6±11.95	75.7±10.61	0.1 (.001%)
E	32	74.8±13.23	76.6±13.54	1.8 (.02%)

Discussion

This section will discuss the significance of the findings in relation to published research.

Muscular Endurance

Muscular endurance is the ability of the muscles to perform work by holding a contraction for a given length of time or by continuing to move a submaximal load to a certain level of fatigue (Ariel, 1983). In this study, upper body muscular endurance was assessed by calculating the total work performed by the upper body muscle groups during a 1 minute bout of alternating arm pulls on the Biokinetic Swim Bench. Posttesting showed that the total work improved significantly in the E Group. There were no changes in total work for W or C.

These results were similar to those of Moffroid and Whipple's findings (1970), which evaluated the effects of two different training speeds on muscular endurance and on muscular force. Two groups trained at either 6 revolutions per minute or 18 revolutions per minute, for 2 minutes, 3 times per week, for 6 weeks. Increase in total work at each training speed for the quadriceps muscle was taken as an index of improvement in muscular endurance. Posttest results showed that the group which trained at 18 revolutions per minute showed greater improvement in endurance of the quadriceps muscle than did the slower group.

The results of this study were also similar to those of Adeyanju, et al. (1983) who trained college females to determine the effects of two speeds of isokinetic training on muscular strength, power, and endurance. A fast speed group trained at 180 deg/sec and a slow speed group trained at 30 deg/sec. Each of the experimental groups performed a program of right and left knee flexions and extensions on the isokinetic Orthroton. Each subject performed three sets of repetitions per training session and each set consisted of 20 seconds of exercise with 30 seconds of rest between sets. The study was conducted for 7 weeks, with a training frequency of 3 days per week. The results indicated significant increases in muscular endurance for the extensor and flexor muscles of both legs, in both of the experimental groups. However, the scores for the fast group were significantly greater than those of the slow group.

Bendle (1985) used a 30 repetition muscular endurance test at 180 deg/sec to measure total work of the hamstring and the quadriceps muscle groups. Posttesting found that for the quadriceps, total work (lb) improved significantly in the groups which trained at 30, 45, and 60 repetitions. For the hamstrings, the group at 30 repetitions was the only group to increase total work significantly.

Similarly, Carr, et al. (1981) compared the effects of fast and slow speed isokinetic training on strength, endurance, and muscle fiber composition of the leg extensor muscles. Their subjects trained one leg at a slow velocity (48 deg/sec) and the other leg at a fast speed (192 deg/sec), 3 days per week for 9 weeks. The total amount of work per workout for each leg was the same. A 2 minute endurance test of the leg extensor muscles at both the fast and slow training speeds was then performed. Muscular endurance improved at both training speeds in both legs tested. The authors suggested that gains in muscular endurance were related to the total work performed.

Total work had been shown to be a reliable measure for clinical use when testing muscular endurance of the quadriceps and hamstrings at either 180 or 240 deg/sec using a standard muscular endurance protocol (Burdett & Van Swearingen, 1987). Their subjects were tested at 180 deg/sec and at 240 deg/sec. Total work was calculated for 25 consecutive quadriceps and hamstring contractions at the designed speeds. It was found to be a clinically very reliable measurement of muscular endurance for these muscles.

In this study, the measure of total work performed by the upper body muscle groups during a 1 minute bout of alternating arm pulls on the Biokinetic Swim Bench served as a measurement of muscular endurance. Using the total work measurement, increases in muscular endurance similar to those reported in the studies reviewed above were obtained.

Our results were most similar to those of Bendle (1985), who found that total work as a measure of muscular endurance increased significantly in the group which exercised their hamstring muscle groups at a lower speed (30 repetitions).

This suggests that the direct relationship between increased speed and increased muscular endurance (which was demonstrated in all the studies reviewed with the exception of Bendle's study) is not consistent across all muscle groups. This suggests that increases in muscular endurance are possible using exercise methods which do not generate high speeds. Exerstriding, which mimics walking, is a low speed exercise which demonstrates significant increases in upper body muscular endurance.

Muscular Strength

According to deVries (1986), the training procedures for the development of muscular strength would be greatly improved if one would know what quantity and quality of stimulus were required to bring about a training effect. The author states that overload conditions must be created in order to elicit strength gains, which means that the muscle must be loaded beyond its normal everyday use in order to cause an adaptive response. According to Muller (1959), the stimulus needed to increase muscular strength is not fatigue, but the force exerted during the job. When this force exceeded one-third of maximum strength, strength gains were made. In other words, approximately 30% of the maximal voluntary contraction is the threshold value at which a training response begins to appear.

It has been suggested that the carrying of light handweights could serve as a stimulus for increasing upper body strength while running (Schwartz, 1982, 1987; Stamford, 1984), but only a few studies have actually investigated the effect of handweights on strength development.

Ewing, et al. (1987) reported no effect on shoulder/elbow strength when subjects trained with or without handweights. They quantified strength improvements by measuring changes in peak torque of the elbow and shoulder flexor and extensor muscles, resulting from 8 weeks of running, while carrying light handweights. They tested 20 male runners, who were randomly assigned to either an experimental or control group. The runners carried light handweights of 0.45 kg. in each hand during Weeks 1 and 2, 0.91 kg. in each hand during Weeks 3 through 5, and 1.36 kg. in each hand during Weeks 6 through 8. The results indicated no significant changes in any of the parameters tested.

In Hoke and Ostrom's study (1983), weighted gloves were used by long distance runners in order to determine if upper extremity muscle groups would show significant strength changes during a 2 month training period. Strength changes were measured in the wrist flexors and extensors, elbow flexors and extensors, and shoulder flexors, extensors, abductors, and adductors using an isokinetic dynamometer. At 60 deg/sec, the experimental group failed to show significant increases in any of the muscle groups tested. At 180 deg/sec, they demonstrated significant strength changes in the elbow flexors and shoulder extensors. At 300 deg/sec, the elbow flexors and extensors exhibited significantly greater changes. Therefore, it was concluded that use of weighted gloves during long distance running increased strength in select upper extremity muscle groups.

In this study, there were no significant changes in upper body muscular strength as assessed by triceps pushdowns and a modified lateral pulldown exercise in any of the groups. Exerstriding is a LR-HR exercise which produces increases in muscular endurance in keeping with the DeLorme Axiom (1945). It may not provide sufficient stimulus to increase upper body strength based upon Muller's criteria (1959).

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to determine changes in upper body muscular strength and endurance as a result of a 12-week walking program in adult women. The investigation was performed on 92 inactive female volunteers, who were between 20-49 years of age. Each subject was randomly assigned to one of three groups and comparisons were made between walking with the Exerstriders (E), walking without the Exerstriders (W), and a control group (C).

The results of the 12-week training program showed that E had a significant increase (37%) in muscular endurance from pre to posttesting, which was greater than the non-significant increases shown by W (14%) and C (5%). There were no significant changes in upper body muscular strength tests in any of the study groups.

It would appear that although walking with the Exerstriders can result in substantial increases in upper body muscular endurance, it may not provide sufficient stimulus to increase upper body muscular strength.

Conclusions

Based on the results of this study, the following conclusions were made:

1. Utilizing Exerstriders while walking increases upper body muscular endurance.

2. Walking with Exerstriders may not provide a sufficient stimulus to increase triceps or lateral pulldown strength.

Recommendations

To further evaluate the effects of walking or walking with Exerstriders on upper body muscular strength and endurance, the following studies are recommended:

1. The same study should be conducted using inactive men as subjects, to determine if similar results would occur.

2. The benefits of walking with the Exerstriders should be evaluated in cardiac patients.

3. A similar study should be conducted with inactive women to determine if Exerstriders provide a means of preventing or delaying the onset of osteoporosis.

4. The same study should be conducted with a different method of assessing strength gains.

5. A similar study should be conducted using a longer training period to define if strength gains occur.

6. A similar study should be conducted using different testing speeds on the Biokinetic Swim Bench.

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APPENDIX A

NEWSPAPER ARTICLE AND FLYER REQUESTING SUBJECTS

La Crosse Tribune, Sunday, June 30, 1991

UW-L will conduct study on effects of exerstriding

By **TERRY RINDFLEISCH**
Of the Tribune staff

The University of Wisconsin-La Crosse will conduct the first training study of a new exercise — exerstriding.

The exercise uses cross-country skis with rubber tips on the end known as "Exerstriders." The 12-week study, done in conjunction with the Wisconsin Heart Institute and Lutheran Hospital, will compare regular walking to exerstriding for aerobic capacity, body composition, muscular strength, endurance and general well-being.

Exerstriding mimics cross-country skiing and can burn 20 to 30 percent more calories than walking alone because more muscles are used during the exercise, according to John Porcari, director of UW-L's La Crosse Exercise and Health Program.

The exercise seems to be more natural than using weights to lift the arms while walking, he said.

Porcari and Nancy Butts, the research director, are looking for 90 to 100 women, age 20 to 49, for the research. Subjects must not smoke and cannot be currently walking more than once a week. They also cannot be on any medications or have any heart or orthopedic problems.

Subjects will be given a series of tests from July 6-15. Some will be in the exerstriding group and some will be in the walking group. They will exercise four times a week until Oct. 1.

For more information on the study, call (608) 785-8689.

EXERSTRIDER

EXERSTRIDER WALKING PROJECT

The La Crosse Exercise and Health Program, in cooperation with Gunderson/Lutheran Medical Complex and the Wisconsin Heart Institute, are seeking 100 females to participate in a 12 week Walking Program.

Eligibility requirements:

1) Between the age of 20 - 49 years old
2) Currently inactive
3) A non smoker
4) No cardiovascular or orthopedic problems

To enroll or obtain additional information call:

785-8689

Monday, July 1~ 7AM - 8PM
Tuesday, July 2~ 7AM - 8PM

APPENDIX B

STUDY QUESTIONNAIRE, INCLUDING PHYSICAL ACTIVITY READINESS QUESTIONNAIRE

QUESTIONNAIRE for EXERSTRIDER STUDY

NAME:__________________________________ **DATE:**

____

ADDRESS:

____

____

______

PHONE (W):________ **(H)** _______ **AGE**___

BIRTHDATE:____________________

YES NO 1. Are you comfortable in water (Hydrostatic weighing)?

YES NO 2. Are you available for Practice/Testing **July 6-14 & October 5-13?**

YES NO 3. Are you willing to train 4 days/week (at least 2 supervised) for 12 weeks during the following times? **6:00-8:00 a.m., 4:00-6:30 p.m., M-F, 8:00-10:00 a.m. Sat.**

YES NO 4. Will you agree to participate regardless of what group (**walking, exerstrider, control**) you are **randomly** assigned to?

YES NO 5. Do you consider yourself to be inactive (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 (i.e., go on a restricted diet, etc.)?

YES NO 8. Are you willing to make a $40.00 deposit to be refunded after final test?

Physical Activity Readiness Questionnaire (PAR-Q)

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? (i.e., medications, etc.)?

Reference: PAR-Q Validation Report. British Columbia Department of Health, June 1975 (Modified Version-ACSM, 1991, p. 37)

YES NO 7. Are you on any medication? If **YES**, please explain.

Do you have any of the following major Coronary Risk Factors?

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: ______________________________

Date: ______________ Time: ________

APPENDIX C

INFORMED CONSENT FORM

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 muscular strength/endurance occur as a result of participating in a walk 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 muscular strength/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 walking program.

The 12-week training program will consist of walking between 20 and 45 minutes, 4 days per week for a total of 48 sessions. Two of these sessions per week must be supervised. Sessions will be individually designed to elicit between 70% and 85% 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.

The **treadmill test** will consist of walking on the treadmill at a speed which I will determine. Once this speed has been selected the grade of the treadmill will be increased 2.5% each 2 minutes until I reach volitional exhaustion. During this test my heart rate will be monitored continuously with a Heart Rate 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 muscular endurance will be determined using a modified Biokinetic Swim Bench. This test requires that I perform a series of contractions with both arms for a total of 1 minute to the point of 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.

Upper body muscular strength will be assessed using a Universal Gym weight lifting machine. This test requires that I perform pushdown and pulldown strength tests of my upper body muscles. The strength assessment on each of the two exercises will be achieved by gradually increasing the amount of weight that could be successfully lifted at one time. This test will leave my arms fatigued for a short time (i.e., probably 5-10 minutes). This fatigue will diminish with no long term effects.

The **personal 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/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 Exerstriders** 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 receive a **free pair of Exerstriders.**

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:______________

APPENDIX D

WEEKLY EXERCISE LOG

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

Setting the pace since 1971

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 E

EXERCISE PRESCRIPTION

<u>EXERSTRIDER/WALKING EXERCISE PRESCRIPTION</u>

For: ____________________

Frequency: 4 exercise sessions per week must be done.

1) At least 2 of the 4 sessions must be done at the UW-L **outdoor track** (or indoor track during inclement weather).

2) If desired, **all** exercise sessions **could** be done at UW-L.

3) Any training done off campus (maximum of 2) must be done on *hill-less* terrain.

4) Each exercise must be logged in your personal logbook. These logbooks will be collected and recorded each week.

<u>Intensity:</u> Your intensity should be monitored by periodic 10 second pulse checks. For a 10 second count, **<u>your</u>** pulse should be between:

____

In addition to pulse checking: *A Rating of Perceived Exertion* should ideally fall between 12 and 15.

Duration:

How long you exercise each session is listed below.

Week #	**Duration**
Week #1	20-25 min.
Week #2	25-30 min.
Week #3	30-35 min.
Week #4	35-40 min.
Week #5	40-45 min.
Week #6	40-45 min.
Week #7	40-45 min.
Week #8	40-45 min.
Week #9	40-45 min.
Week #10	40-45 min.
Week #11	40-45 min.
Week #12	40-45 min.

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.