

ABSTRACT

DORONIO, D.R. The effect of arm exercise on the energy cost of StairMaster stepping in males. MS in Exercise and Sport Science-Human Performance, May 1995, 50pp. (N. K. Butts)

This study compared the metabolic responses of StairMaster 4000PT (SM) stepping with the addition of upper body exercise (WA) using the UB Sports Fitness Trainer (UBSFT) to SM stepping with no arm use (WOA). Step depth WA and WOA were also biomechanically analyzed. Twenty-two active males (19-32 yrs) completed 2, 20-minute tests on the SM. The tests consisted of stepping at 4, 5-min workrates (3, 5, 7, and 9). Two alternating workrates required arm usage on the first testing day and the other two workrates on the second testing day. During all tests expired air was analyzed using open circuit spirometry, HR and RPE were recorded, and step depth was videotaped. The results indicated VO_2 ($L \cdot \text{min}^{-1}$, $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, METS), RER, and step depth WA were significantly ($p < .05$) greater than WOA across all workrates. However, there were no significant ($p > .05$) differences WA or WOA at a given workrate. HR and RPE were not significantly ($p > .05$) different WA or WOA across all workrates. With the exception of step depth between workrates 7 and 9, VO_2 ($L \cdot \text{min}^{-1}$, $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, METS), HR, RPE, V_E , and RER were significantly ($p < .05$) greater with increasing workrates. V_E and RER were significantly ($p < .05$) greater for the WOA at workrate 9. It was concluded that use of the UBSFT elicits similar energy costs as unsupported stepping.

THE EFFECT OF ARM EXERCISE ON THE
ENERGY COST OF STAIRMASTER
STEPPING IN MALES

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
DAMIAN R. DORONIO

MAY 1995

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

THESIS FINAL ORAL DEFENSE

Candidate: Damian R. Doronio

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

Master of Science in Physical Education - Human Performance

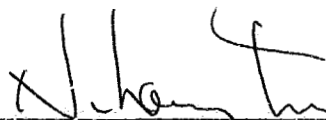
The candidate has successfully completed his final oral examination.



Thesis Committee Chairperson Signature

4-11-95

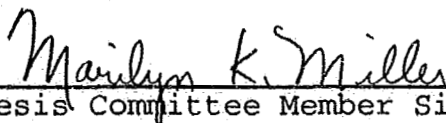
Date



Thesis Committee Member Signature

4-12-95

Date

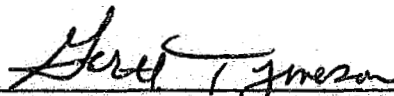


Thesis Committee Member Signature

4-12-95

Date

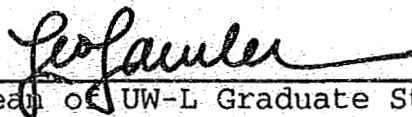
This thesis is approved by the College of Health, Physical Education, and Recreation.



Associate Dean, College of Health,
Physical Education, and Recreation

5-2-95

Date



Dean of UW-L Graduate Studies

4 May 1995

Date

ACKNOWLEDGEMENTS

I would especially like to thank Dr. Nancy Butts, my committee chair, and Dr. Marilyn Miller for their assistance and persistence in helping to complete this paper. I would also like to thank Dr. Laury LePage for graciously taking over a position on the thesis committee under less than ideal circumstances.

I would like to give special thanks to the faculty and staff particularly Dr. Garth Tymeson and Dr. William Floyd for guiding and structuring my curriculum to complete the Exercise and Sport Science-Human Performance Program. I would also like to thank my classmates in the program for being friends and subjects.

I would like to thank my family and friends outside of the University who kept me motivated at home and at work. Their support helped relieve the anxiety and stress I confronted while completing the required course work and paper for this degree. These individuals include Mr. and Mrs. Robert Mills, Diana Doronio, Nichole LaMere, and Patrick Foley.

Finally, I would like to thank my father Toby Doronio for earning a Master's degree at the University of Wisconsin-LaCrosse, and inspiring me to do the same.

TABLE OF CONTENTS

	PAGE
ACKNOWLEDGEMENTS	iii
LIST OF TABLES	vii
LIST OF FIGURES	viii
LIST OF APPENDICES	ix
CHAPTER	
I. INTRODUCTION	1
Background	1
Purpose of the Study	2
Hypotheses	3
Assumptions	3
Delimitations	4
Limitations	5
Definition of Terms	5
II. REVIEW OF RELATED LITERATURE.....	7
Introduction	7
StairMaster Studies.....	7
Training Studies.....	7
StairMaster Compared to the Treadmill.....	8
Self-Selected Stepping.....	9
Effect of Holding Position.....	9
Energy Consistency.....	10
Combined Upper and Lower Body Exercise.....	10
Cross Training Effects.....	10

CHAPTER	PAGE
Treadmill Walking.....	11
Effect of Hand Support While Treadmill Walking.	13
Summary.....	13
III. METHODS AND PROCEDURES.....	15
Pilot Study.....	15
Subject Selection	17
Practice Session.....	18
Testing Procedures.....	19
Biomechanical Analysis.....	21
Statistical Treatment.....	22
IV. RESULTS AND DISCUSSION	24
Introduction	24
Subject Descriptive Data.....	24
Results.....	25
Discussion.....	27
Energy Cost.....	27
Step Depth.....	31
Heart Rate and RPE.....	32
Ventilation and RER.....	33
V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS	35
Summary	35
Conclusions	36
Recommendations for Future Study.....	37

	PAGE
REFERENCES	39
APPENDICES	43

LIST OF TABLES

TABLE	PAGE
1. StairMaster workrate and metronome setting in steps per minute.....	20
2. Age, height, and weight of the subjects.....	25
3. Means and standard deviations of the physiological variables, RPE, and step depth at StairMaster workrates 3, 5, 7, and 9 with and without arm use.....	26
4. Summary of StairMaster research on males.....	28

LIST OF FIGURES

FIGURE	PAGE
1. Mean values of RER with and without arms.....	34
2. Mean values of ventilation with and without arms..	34

LIST OF APPENDICES

APPENDIX	PAGE
A. Activity Questionnaire.....	43
B. Informed Consent.....	45
C. Borg Scale- Rating of Perceived Exertion.....	47
D. Manufacturers Exercise Guidelines.....	49

CHAPTER I
INTRODUCTION

Background

Pursuit of a mode of exercise which expends numerous kilocalories in the least amount of time has made total body exercise or combined arm/leg exercise particularly favorable for many individuals. These individuals are often seen walking while swinging hand weights or simulating cross country skiing on a NordicTrack machine. The advantage of these exercise methods is combining upper and lower body exercise to achieve both cardiovascular and resistance conditioning in a single workout. SportsTech Services-Incorporated (Tulsa, OK) has recently developed an upper body training device designed for use on the model 4000PT StairMaster (StairMaster-Inc., Kirkland, WA). The exercise device, UB Sports Fitness Trainer, mounts on the front hand rail of the stepper and provides upper body conditioning via a right and left arm bar.

The combination of upper and lower body exercise has been shown to increase energy expenditure. For example, the use of hand weights while walking or running has been found to increase energy cost (Auble & Schwartz, 1991). They reported that the magnitude of the energy increase was

proportional to the distance the hand weights were moved. The application of this finding provides an individual one method to use upper body exercise to increase energy cost without having to increase running or walking speed.

Numerous other methods of adding arm work during exercise have been attempted. Stanforth and Stanforth (1993) studied the effect of adding external weight to a waist-attached dive belt while subjects bench stepped. These authors found significantly greater energy costs were required as more weight was added to the belt through all bench step heights. Jordan (1992) and Olson, Williford, Blessing, and Greathouse (1991) found adding arm work into bench step aerobics routines increased the energy cost an average of 6 to 7%. Butts, Knox, and Foley (1995) studied the effect of adding arm exercise to submaximal treadmill walking at three speeds. These researchers found significantly greater energy costs for the arm use trials over the no arm use trials at all speeds tested. At the present time no studies have been published reporting the energy cost on the UB Sports Fitness Trainer which incorporates simultaneous arm movement into StairMaster stepping.

Purpose of the Study

The purpose of this study was to compare the metabolic responses of StairMaster stepping with the addition of upper

body exercise using the UB Sports Fitness Trainer to StairMaster stepping with no arm use. A secondary purpose of this study was to compare the difference in step depth between the arm use condition and the no arm use condition.

Hypotheses

The following null hypotheses were tested:

1. There is no significant difference in energy cost between stepping with arm exercise and stepping without arm exercise at StairMaster workrates of 3, 5, 7, and 9.
2. There is no significant difference in step depth between stepping with arm exercise and stepping without arm exercise at StairMaster workrates of 3, 5, 7, and 9.

Assumptions

The following assumptions were made in this study:

1. It was assumed the subjects had not eaten, used tobacco products, or consumed caffeine/alcohol for at least 3 hours prior to their test.
2. It was assumed the subjects had not engaged in strenuous physical activity on their scheduled test days.
3. Steady state was assumed to be achieved during the last two minutes of each workrate.
4. It was assumed the resistance setting of the arm handles remained constant during every testing session.

5. It was assumed one practice session was sufficient to familiarize each subject with the testing protocol and the equipment.

Delimitations

The following delimitations were present in this study:

1. The subjects for this study were active males between the ages of 19 and 32 years.
2. At least one practice session was scheduled for all participants in the study.
3. A standardized hand position on the UB Sports Fitness Trainer and an upright posture were required during all arm exercise trials.
4. A standardized range of movement of both the right and left arm bars on the UB Sports Fitness Trainer was required during all arm exercise trials.
5. Two testing sessions at least 48 hours apart were scheduled for all the participants. One of two exercise sequences was randomly assigned to each subject on the first testing day.
6. Stepping cadence for each workrate on the StairMaster was set by a metronome at rates indicated by the company.

Limitations

The following limitations were present in this study:

1. The subjects used for this study were male volunteers between the ages of 19 and 32 which may not represent the heterogenous population.
2. The previous knowledge, experience, and coordination of the subjects on the StairMaster may have influenced the results.
3. The use of the UB Sports Fitness Trainer for upper body exercise was a novel task for all the subjects.
4. The resistance provided by the UB Sports Fitness Trainer was only incorporated into the pull phase of the arm bars, not in the push phase of the arm bars.

Definition of Terms

Active Individuals - individuals who exercise at least three times per week for 20 minutes or more as determined by the activity questionnaire (see Appendix A).

Energy Cost - the metabolic levels determined by computerized gas analysis via open circuit spirometry (Q-Plex I, Quinton Instruments, Seattle, WA). Energy cost or oxygen consumption was expressed interchangeably by METS, $L \cdot \text{min}^{-1}$ and $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$.

Lower Body Exercise - stepping movement of the legs on the StairMaster at a specified workrate.

Lower and Upper Body Exercise - stepping movement of the legs on the StairMaster at a specified work rate with coordinated arm exercise using the UB Sports Fitness Trainer.

METS - "A multiple of the resting rate of O_2 consumption (VO_2). One MET equals VO_{2rest} which is approximately $3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$; it represents the approximate rate of O_2 consumption of a seated individual at rest" (American College of Sports Medicine (ACSM), 1991, p. 287).

UB Sports Fitness Trainer (SportsTech Services, Inc.) - a device which mounts on the front hand rail of the StairMaster 4000PT and provides upper body exercise by curvilinear movement of right and left arm bars in the sagittal plane. Resistance settings for the Sports Fitness Trainer range from 1 to 10.

Upright Posture - an erect stature with the vertebral column perpendicular to the floor.

Workrate - a rate set on the StairMaster 4000PT's computer which range from 1 to 14.

Step Depth - the linear displacement of the right pedal as determined by the distance between the top of its travel (vertically) and the lowest point of its depression.

CHAPTER II
REVIEW OF RELATED LITERATURE

Introduction

The use of a conventional activity (walking up stairs) has been transformed into a popular means to aerobic fitness by the StairMaster company. This company has developed two types of stepping machines. The first type (SM Gauntlet) uses revolving steps that have a fixed distance between each step. The second type (SM 4000PT) has right and left pedals which allow the user to vary the rate or depth of step while at a given workrate. A limited amount of research has been conducted on either type of these stepping machines, and no research has been conducted on the physiological effects arm exercise would have if incorporated into the stepping.

The purpose of this literature review was first to summarize the research on both types of the StairMaster models, and second, to review literature concerned with combined upper and lower body exercise.

StairMaster Studies

Training Studies

The credibility of stepping machines as an effective training modality has been tested by several researchers (Ben-Ezra & Verstraete, 1991; Loy & Holland, 1990;

Rosentsweig, Verstraete, & Basset, 1986; Wescott, Greenberger, & Anderson, 1990). These studies found StairMaster workouts ranging from 15 to 50 minutes, three times per week, increased peak VO_2 by 11 to 36%. The training duration between the studies varied from 8 to 12 weeks. Only the study by Wescott et al. (1990) used the pedal type StairMaster (4000PT) to train the subjects.

StairMaster Compared to the Treadmill

Many studies have contrasted the revolving staircase type steppers with the treadmill. Ang, Fahey, Klatt, and Williams (1993) and Verstraete and Ben-Ezra (1987) compared the physiological responses between the StairMaster and the treadmill at equivalent submaximal workloads. These researchers found no significant differences between the modalities. Ben-Ezra and Verstraete (1988) and Holland, Hoffmann, Vincent, Mayers, and Caston (1990) compared differences in peak VO_2 between the StairMaster and the treadmill. Ben-Ezra and Verstraete (1988) found peak VO_2 was 7% higher on the treadmill while Holland et al. (1990) found equal peak VO_2 levels between the two exercise modes.

Peak VO_2 has also been studied on the StairMaster 4000PT (Luketic, Hunter, & Feinstein, 1993; Riddle & Orringer, 1990). These researchers found the maximum energy cost obtained on the StairMaster ranged between 13.1 and 13.8 METS and concluded that the highest workrate on the

StairMaster could not elicit peak VO_2 in highly fit subjects. The inability of the pedal type StairMaster to produce maximal exertion in well fit individuals confines its use to submaximal exercise.

Self-Selected Stepping

The energy cost of self-selected stepping versus set cadence stepping on the StairMaster 4000PT at equivalent workrates has been investigated (Butts, Dodge, & McAlpine, 1993; Howley, Colancino, & Swenson, 1992). These studies found no significant differences in the energy cost between the two stepping methods. It should be noted that normal usage of the StairMaster allows individuals to vary the stepping depth and/or stepping frequency within a workrate. The above studies, however, indicate it is inconsequential on the energy cost whether a stepping frequency is imposed or not imposed during a workrate.

Effect of Holding Position

Numerous studies (Bideaux, Wygand, Otto, Helgemore, & Kosilla, 1991; Butts, 1994; Howley et al., 1992; Luketic et al., 1993) have considered the effect of hand positions on energy cost when stepping on the StairMaster 4000PT. These studies found the use of hand support while stepping required significantly less energy cost than stepping without the use of hand support. The difference in energy cost between the positions were found to be larger when

subjects stepped at higher workrates (i.e. 7, 9, 11, and 13). The reduction in energy cost for the hand support trials in these studies was most likely due to the distributed effort between the upper and lower body to support the body weight.

Energy Consistency

An unpublished study by Butts and Dodge (1993) found the StairMaster 4000PT provided consistent energy costs in subjects at workrates 5, 7, 9, and 11. Subjects in the study stepped at a self-selected rate and were tested on five consecutive days at the same time each day. The authors also reported that the variability in energy cost between subjects was approximately 6% which was comparable in magnitude to similar studies using walking or running.

Combined Upper and Lower Body Exercise

Cross Training Effects

Several training studies (Lewis, Thompson, & Areskog, 1980; Stamford, Cuddihee, Moffatt, & Rowland, 1978; Thompson, Cullinane, Lazarus, & Carleton, 1981) have evaluated the possible cross training effects of the legs to the arms or vice versa. These studies compared the pre- and postconditioning peak arm and leg VO_2 of arm trained subjects with leg trained subjects. Results of the studies found cross training effects to be nonexistent or restricted to a generalized training effect. These studies imply that

large increases in upper body aerobic capacity will not be gained by lower body exercise alone. The use of combined upper and lower body exercise, therefore, may be a credible alternative for those interested in total body fitness.

Treadmill Walking

The effect of adding arm exercise to treadmill walking has been investigated (Butts et al., 1995; Porcari et al., 1994). These studies incorporated upper body exercise via right and left arm handles that provided bidirectional (push/pull) resistance in the sagittal plane. Porcari et al. (1994) compared the energy costs of a self-propelled treadmill (NordicTrack-Walkfit) with added arm exercise to unsupported walking on a motorized treadmill at four submaximal speeds. An average increase of 51% in energy cost was found when arms were incorporated into the walking. Butts et al. (1995) compared energy cost between walking with arm exercise and walking without arm exercise on a motorized treadmill (CrossWalk) at three submaximal speeds. These researchers found an average 55% energy cost increase when arms were incorporated into the walking.

The energy cost of using bidirectional arm swing in the sagittal plane while treadmill walking has also been investigated (Auble, Schwartz, & Robertson, 1987; Francis & Hoobler, 1986; Maud, Stokes, & Stokes, 1990). Maud et al. (1990) compared four variations of treadmill walking: (1)

walking normally; (2) walking normally with 3 lb weights; (3) walking with a vigorous arm swing; and, (4) walking with a vigorous arm swing using 3 lb weights. These researchers found an increased energy cost for the hand weight trials with a combined increase in stride length. They concluded that the increase in stride length may negate the increase in energy cost found during the hand weighted trials. A significant increase in energy cost, however, was also found for unweighted vigorous arm swings when compared to normal walking.

Francis and Hoobler (1986) compared the energy cost of both walking and running on the treadmill while using hand weights at three submaximal speeds. The authors found that walking with hand weights did not alter energy cost. The incorporation of hand weights while running, however, did require a small yet significantly greater energy cost. The authors concluded that the benefits of a small increase in energy cost while running with hand weights did not outweigh the additional stress placed on the lower body by the hand weights.

Auble et al. (1987) investigated the effect of varying pounds of hand weight and arm swing on energy cost at four submaximal treadmill speeds. The authors found that increasing the pounds of the hand weight, and increasing the height of the arm swing (individually or collectively)

significantly increased the energy cost over walking without hand weights. The increases in energy cost reported by these authors when compared to normal walking ranged between 113 to 255%.

Effect of Hand Support While Treadmill Walking

The effect of using the upper body as a source of support while treadmill walking has also been investigated (McConnell, Foster, Conlin, & Thompson, 1991; von Duvillard & Pivirotto, 1991). Both of these studies compared the energy cost of exercising to maximal exertion while using hand rail support with exercising to maximal exertion without hand rail support at equivalent speeds on a treadmill. These researchers found that the use of hand support (upper body support) reduced the energy cost at all submaximal speeds tested. Both of these studies, however found that using hand support increased the length of time subjects were on the treadmill, but did not affect the maximal energy cost.

Summary

The research reviewed on the StairMaster indicated that exercising on the modality three times a week for a minimum of 15 minutes is sufficient to produce a training effect. The use of hand support while stepping significantly reduces the energy cost when compared to unsupported stepping. The use of cadenced stepping or self-selected stepping at a

workrate produces equivalent energy costs. The workrates on the StairMaster provide consistent energy costs.

Recently an upper body exercise device (UB Sports Fitness Trainer) has been manufactured by SportsTech Services Inc. (Tulsa, OK). The exercise device mounts on the front hand rail of the StairMaster 4000PT and is designed to provide upper body exercise via right and left arm bars. The UB Sports Fitness Trainer proposes to: 1) increase cardiovascular intensity (energy cost) when coordinated with the lower body stepping; and 2) provide upper body strength and endurance conditioning. The use of similar novel upper body conditioning devices used during walking suggest the claims made by the company for increased energy cost while stepping may be substantiated (Butts et al., 1995; Porcari et al., 1994). Studies that have combined hand weights with walking or running, however, have found less consistent energy cost results. Some studies reported no energy cost increases while others reported large energy cost increases. The varied results of these studies, however, is most likely attributed to the range of motion and vigor of the arm swings incorporated into the walking or running. Research conducted on the energy cost elicited by the UB Sports Fitness Trainer while stepping will provide guidelines to prescribe safe and effective exercise regimens when using the modality.

CHAPTER III
METHODS AND PROCEDURES

Pilot Study

A pilot study was undertaken to establish an appropriate resistance setting, hand position, and movement range of the arm bars on the UB Sports Fitness Trainer. The setting of six on the UB Sports Fitness Trainer was found to be an appropriate arm resistance for males. Criteria for choosing this resistance were subjectively based on establishing a setting for the arms that would allow subjects to be challenged when upper body use was required, but not completely exhausted.

The placement of the hands on the UB Sports Fitness Trainer's arm bars was also standardized, but allowed each subject to choose from two positions. The hands were required to be placed on either the upper or lower hand bar. Criteria for this decision were based upon omniscient observation by this researcher while individuals were asked to perform exercise using the UB Sports Fitness Trainer. It was observed that taller subjects preferred the upper hand position, while shorter subjects preferred the lower hand position. In actual testing, therefore, the choice of which

hand bar to hold was left to the subject's own preference but was consistent at all workrates.

The movements of the right and left arm bars of the UB Sports Fitness Trainer were also standardized. Movement of the arm bar in the push phase required the subject to extend his arm, such that the forearm and upper arm were in a straight line. The simultaneous pull phase of the opposite arm bar required the subject to retract the bar to within 6 inches of the trunk. The criterion for this decision was to establish an equivalent upper body movement of the arm bars for all the subjects regardless of their physical stature.

Five subjects (2 male, 3 female) were then tested at workrates 5 and 7 on the StairMaster. The two conditions of the testing were then contrasted: 5 arms versus 5 no arms; 7 arms versus 7 no arms. When all metabolic responses, including the measurement of heart rate and rating of perceived exertion were compared, it was concluded that there were no apparent differences between any variable when the arm trials were compared with the no arm trials at the same workrates.

A biomechanical analysis of one female subject was then undertaken to determine if there were lower body differences between stepping while using the arms and stepping without using the arms at workrate settings of 3, 5, 7, and 9 on the StairMaster. The biomechanical analysis found that at all

workrates the arm trials required a slower stepping rate than the no arm trials. It was decided, therefore, to use a metronome to equate stepping rate in the arm use and the no arm use conditions at each workrate. In addition, a camcorder to videotape the stepping movement of each subject was incorporated into the final testing protocol. It was hoped that the biomechanical analysis of step depth would help answer the question of why there were minimal differences in energy cost between the arm use and the no arm use conditions observed during the pilot study. In conclusion, the pilot study data and observations finalized the testing procedures of this study.

Subject Selection

The subjects for this study consisted of 22 male volunteers between the ages of 19 and 32 years. The subjects were obtained from the LaCrosse, WI area and every subject, except one attended the University of Wisconsin-La Crosse (UW-L). Each subject was telephoned the night prior to the testing and asked to abstain from eating, using tobacco products, and consuming caffeine or alcohol for at least 3 hours prior to their test time. The subjects were also asked to wear appropriate work out clothing and shoes (i.e., t-shirt, shorts, and exercise shoes). The subjects were also asked to refrain from any strenuous exercise prior to their scheduled testing time. Upon arrival at the test

site each subject was asked to complete an activity questionnaire (see Appendix A) and informed consent form (see Appendix B). A verbal description of the apparent risks, dangers, and potential benefits of the study were communicated to the subject. Any questions the subjects asked concerning the study or the testing procedure were also answered. All weights and heights of the subjects were taken on a physician style scale located in the UW-L Human Performance Laboratory.

Practice Session

Each subject was required to perform at least one practice session. This session allowed each subject to become familiar with both the arm use and the no arm use conditions while stepping on the StairMaster and using the UB Sports Fitness Trainer. A demonstration was given by the test administrator that included: (a) how to step rhythmically on the StairMaster; (b) how to coordinate the arms with the stepping; (c) the range of motion required for the arm bar movement; (d) how to maintain an upright posture while stepping during the arm trials; (e) proper operation of the StairMaster computer console; and, (f) how to properly adjust the nose clip and head gear. Additionally, each subject was given the following instructions on rating his perceived exertion:

During the test you will be asked to rate your exertion on a scale from 6 - 20 (see Appendix C). The rating of (6) means you are practically sleeping, and the rating of (20) means you are completely exhausted. You should rate your exertion based on your total feeling of the intensity. This meaning, you should not just rate how exerted your legs feel or how exerted your arms feel, but your total inner feeling of the physical exertion.

The subject was also instructed not to place his hands on the StairMaster when upper body exercise was not required. It was verbally communicated to the subject that the hands were to be used only to prevent falling during the no arm trials. Each subject was then required to exercise with the head gear on at a submaximal workrate of 3 on the StairMaster without holding the hand rails. Following the subjects' familiarization of this condition, they were instructed to coordinate the upper body exercise with a metronome set stepping pace. Upon satisfactory completion of these conditions the subject was scheduled for testing.

Testing Procedures

The subjects performed 4, 5-minute workrates (3, 5, 7, and 9) on the StairMaster 4000PT. Two alternating workrates required arm usage on the first testing day, and the other two workrates on the second testing day. The arm rate was in cadence to the stepping rate in accordance with the manufacturer's instructions on proper exercise technique using the UB Sports Fitness Trainer (see Appendix D). The upper body resistance setting of 6 on the UB Sports Fitness

Trainer was calibrated with a dynamometer prior to each testing session. The metronome settings used to equalize the stepping rates of the arm and no arm conditions are presented in Table 1.

Table 1. StairMaster workrate and metronome setting in steps per minute

StairMaster workrate	Steps per minute
3	48
5	69
7	88
9	108

Each subject was fitted with a heart rate monitor (UNIQ-CIC; Computer Instruments Corporation, Hemstead, NY). The strap component of the monitor was fastened around the subject's chest. This component senses the electrical impulse of a heart contraction and relays it by telemetry to a second component which is a watch. The watch then converts these electrical impulses to a heart rate in beats per minute. Heart rate was recorded each minute of testing by the test administrator.

Expired air was collected by open circuit spirometry using a computerized gas analyzer (Q-Plex 1, Quinton Instrument Company, Seattle, WA). This system provides an analysis of ventilation volumes, absolute and relative

oxygen consumptions, METs, and the respiratory exchange ratio. Calibration of this system was performed before each subject was tested using gases of a known percentage determined by the Scholander technique. Slow, medium, and fast flow rates using a 3.002-l syringe pump were used to calibrate the Q-Plex's flow meter volume prior to each test. Rating of perceived exertion on the Borg scale was determined during the last minute of each workrate. Steady state was determined from the last 2 minutes of each 5-minute workrate. A steady state value was accepted if the oxygen uptake during the last 2 minutes of a workrate did not deviate by more than $1 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$. An average of these two minutes were used in the final statistical analysis.

Biomechanical Analysis

Each subject was videotaped during the last minute of a workrate using a CVM-310 Magnavox camcorder with automatic focus (Magnavox, Trenton, NJ). The camera was held stationary on a tripod and positioned 3.43 m directly behind the StairMaster with the lens perpendicular to the stepping action. The lens's vertical height from the ground was 0.40 m. These camera to StairMaster distances were used consistently to videotape all the subjects. The focus of the lens captured each subject's waist and leg stepping motion on the StairMaster. A reference stick 60.96 cm in

height was placed 3.81 cm to the side of the right pedal on the StairMaster. Reflective markers were placed on the reference stick at 0, 15.24, 30.48, and 45.72 cm, and on the right StairMaster pedal.

The videotape data obtained for all workrates (arm and no arm conditions) were reduced using an Ariel Performance Analysis System - Systems Diversified, Provo, UT (APAS). Videotaped stepping sequences of all workrates (arm and no arm conditions) of each subject were converted from an analog to a digital signal (grabbed) and stored on computer. The grabbed sequences were further digitized and transformed using APAS. Data were smoothed using a cubic spline filter. Linear displacement of the step was determined by finding the distance between the highest vertical point of the step's travel and the lowest vertical point of the step's depression.

Statistical Treatment

The metabolic responses of ventilation, VO_2 ($L \cdot \text{min}^{-1}$, $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, METS), RER, heart rate, and RPE during stepping were contrasted to the same metabolic responses of stepping with the addition of upper body exercise at each workrate. A two-way ANOVA (arm and workrate) with repeated measures was used to determine if there were differences in responses during arm versus no arm stepping at the .05 level

of confidence. When appropriate a Tukey post hoc comparison was used to analyze statistically significant variables.

CHAPTER IV
RESULTS AND DISCUSSION

Introduction

The purpose of this study was to compare the energy cost of stepping on the StairMaster incorporating arm exercise using the UB Sports Fitness Trainer to stepping without arm usage. Twenty-two active male volunteers from the LaCrosse, WI area completed two tests on the StairMaster 4000PT. The tests consisted of stepping at workrates 3, 5, 7, and 9 with and without arm exercise. The variables of oxygen consumption VO_2 ($L \cdot \text{min}^{-1}$, $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, METS), heart rate (beats per minute), rating of perceived exertion (RPE), respiratory exchange ratio (RER), ventilation (V_E), and step depth were measured each minute throughout the tests.

The results were then statistically analyzed using a mixed design two-way ANOVA with repeated measures. The ($p < .05$) level of confidence was used to accept or reject the null hypotheses. When appropriate a Tukey post hoc analysis was performed on those variables that were statistically significant.

Subject Descriptive Data

The means, standard deviations, and ranges for the age, height, and weight of the subjects are presented in Table 2.

Table 2. Age, height, and weight of the subjects
($N = 22$)

Variable	Mean	SD	Range
Age (yrs)	22.4	3.7	19.0 - 32.0
Height (cms)	130.1	6.4	67.0 - 75.0
Weight (kgs)	79.2	9.3	58.8 - 94.6

Results

Data were obtained for the variables VO_2 ($L \cdot \text{min}^{-1}$, $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, METS), heart rate, RPE, RER, V_E , and step depth at StairMaster workrates 3, 5, 7, and 9 for both arm and no arm conditions (see Table 3). The main effect of arms indicated that VO_2 ($L \cdot \text{min}^{-1}$, $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, METS), RER, and step depth during arm usage were significantly ($p < .05$) greater than the no arms condition across all workrates. However, there were no significant ($p > .05$) differences between arms and no arms at a given workrate. Heart rate and RPE were not significantly ($p > .05$) different between arms and no arms across all workrates. With the exception of step depth between workrates 7 and 9, VO_2 ($L \cdot \text{min}^{-1}$, $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, METS), heart rate, RPE, V_E , and RER were significantly ($p < .05$) greater with increasing workrates.

Table 3. Means and standard deviations of the physiological variables, RPE, and step depth at StairMaster workrates 3, 5, 7, and 9 with and without arm use (N = 22)

Variables	Workrate 3		Workrate 5		Workrate 7		Workrate 9	
	Arms	No Arms	Arms	No Arms	Arms	No Arms	Arms	No Arms
VO ₂ ^{1,3} (L·min ⁻¹)	1.72 ^a 0.25 ^b	1.62 0.18	2.18 0.24	2.04 0.26	2.60 0.33	2.57 0.33	3.12 0.41	3.07 0.36
VO ₂ ^{1,3} (ml·kg ⁻¹ ·min ⁻¹)	21.67 1.94	20.58 0.97	27.50 2.31	25.71 1.44	32.83 2.30	32.33 1.90	39.38 2.91	38.72 1.91
HR ¹ (bpm)	120.86 9.87	119.27 15.83	138.04 14.82	137.73 12.54	154.86 11.43	154.68 15.26	168.82 12.97	171.45 12.14
RPE ¹	7.77 1.34	7.64 1.36	10.41 1.62	10.36 1.22	12.45 0.86	12.50 1.26	14.63 1.43	14.81 1.18
METS ^{1,3}	6.18 0.56	5.88 0.56	7.86 0.66	7.34 0.41	9.38 0.65	9.23 0.54	11.25 0.83	11.06 0.55
Step ^{2,3} Depth	6.77 2.03	5.90 2.05	8.10 1.70	8.01 1.90	9.50 1.64	9.01 1.82	10.26 1.42	10.00 1.64

Note.

a = mean

b = standard deviation

1 = Workrate 9 > 7 > 5 > 3

2 = Workrate 7 > 5 > 3

3 = Arms significantly (p < .05) higher than No Arms

The V_E and RER were significantly ($p < .05$) greater for the no arms condition over the arms condition at workrate 9. These variables, however, both significantly ($p < .05$) increased with each ascending workrate (i.e., workrate 9 > workrate 7 > workrate 5 > workrate 3). No other significant ($p < .05$) differences were found between the arm and no arm conditions at the workrates tested.

Discussion

Energy Cost

As expected stepping at increasing workrates required significantly greater metabolic demands as demonstrated by the higher VO_2 at each successive workrate. This finding was expected since each ascending workrate required a faster stepping rate thus an increase in total work.

Previous StairMaster research. The energy cost for the no arm stepping trials in this study agree with the energy costs obtained by previous researchers (Bideaux et al., 1991; Butts et al., 1993; Butts, 1993). This was true whether the data were compared to a cadenced stepping rate or a self-selected stepping rate. In contrast, other studies (Howley et al., 1992; Riddle & Orringer, 1992) reported a lower energy cost at equivalent workrates than those obtained in the present study. These studies allowed subjects to hold the support rails while stepping. Their values agree with the hand supported stepping energy values

reported by Butts (1993). The energy cost data from these previous studies are summarized in Table 4.

Table 4. Summary of StairMaster research on males

	Workrate 3	Workrate 5	Workrate 7	Workrate 9
Investigator(s) reported MET levels				
Present Study n = 22	5.88 ^{ac}	7.34 ^{ac}	9.23 ^{ac}	11.06 ^{ac}
Butts (1993) n = 15	----	7.50 ^{bc} 6.40 ^d	9.50 ^{bc} 7.80 ^d	11.30 ^{bc} 10.40 ^d
Butts, Dodge, & McAlpine (1992) n = 14	----	7.35 ^{ac} 7.69 ^{bc}	9.09 ^{ac} 9.28 ^{bc}	10.82 ^{ac} 11.13 ^{bc}
Bideaux, Wygand, Otto, Helgemoe, & Kosilla (1991)** n = 12	----	7.80 ^{bc*}	9.40 ^{bc*}	11.10 ^{bc*}
Howley, Colancino, & Swenson (1992)** n = 6	5.03 ^{bd*}	6.74 ^{bd*}	8.46 ^{bd*}	----
Riddle and Orringer (1991)** n = 16	5.05 ^{bd}	6.35 ^{bd}	7.85 ^{bd}	9.50 ^{bd}

Note.

a = Cadenced stepping

b = Self-selected cadence

c = Non-supported stepping

d = Hand supported stepping

* = Gender not reported

** = Adjusted rate: Workrate 3 = 6 METS, Workrate 5 = 8 METS,
Workrate 7 = 10 METS, Workrate 9 = 12 METS

Arm use versus no arm use. Overall, incorporating arm activity resulted in higher energy costs than stepping without arms. These results are consistent with studies which incorporated arm activity during walking (Auble & Schwartz, 1991; Butts et al., 1995; Porcari et al., 1994). Porcari et al. (1994) found a 51% increase in energy cost when incorporating arm exercise into self-propelled treadmill walking. This arm exercise involved the movement of right and left arm handles in a push/pull sagittal plane motion simultaneous to the walking. Similarly, Butts et al. (1995) found a 55% increase in energy cost when incorporating arm exercise via right and left arm handles into motorized treadmill walking. Auble and Schwartz (1991) reported an average 79% energy cost increase when hand weighted bidirectional arm swings in the sagittal plane were incorporated into walking. The higher increases were found when the arm swing was maximal with the heaviest weight. The magnitude of energy cost increase found in these studies for the arm exercise trials compared to the no arm trials however was much greater than the 3.9% increase in energy cost found for the arm trials in this study.

The lower percentage of energy cost increase found during stepping with arm activity may be attributed to the design of the arm exercise device, and the direction of the lower body exercise with regards to the upper body exercise.

Porcari et al., (1994) and Butts et al., (1995) incorporated upper body exercise devices into treadmill walking that provided bidirectional (push/pull) resistance in the sagittal plane. In addition, the simultaneous lower body exercise (walking) was conducted in the same sagittal plane and similar horizontal direction as the upper body exercise. The arms were prevented from pressing vertically downward on the arm handles and reducing the energy cost. In contrast, the UB Sports Fitness Trainer utilized in this study only provided unidirectional (pull) resistance in the sagittal plane. The arm bars of the UB Sports Fitness Trainer mechanically pushed themselves forward by spring recoil. Additionally, the arm bars in the pull phase moved in a curvilinear path (backward/downward) while the lower body stepping motion was vertically up and down. This provided a potential means for the upper body to partially support the body weight especially at the end of the pull phase and reduce the energy cost.

Butts (1994) researched the effect of hand holding the StairMaster 4000PT's support rails (supported stepping) versus unsupported stepping (no hand hold) at equivalent workrates. Results of the study found that there was an approximate 23% decrease in energy cost when subjects were allowed to hold on support rails. McConnell et al. (1991) and von Duvillard and Piviroto (1991) both found an

approximate 20% decrease in energy cost for hand supported treadmill walking compared to unsupported treadmill walking at equivalent submaximal speeds. The above studies indicate that any form of upper body support during submaximal exercise reduces the energy cost. The UB Sports Fitness Trainer might, as discussed previously, allow support as well as additional work during stepping. Filming of the subjects, however, occurred from the hips down so it is difficult to confirm this.

Step Depth

The step depth was found to be significantly greater for the arms trials. The energy cost of stepping is determined by both the stepping rate and the step height (ACSM, 1991 p. 291). An increase in stepping height and/or stepping rate increases the energy cost of stepping. This study set a stepping rate for each workrate tested which theoretically prevented variations in stepping rate between the arms and no arms trials. The greater step depth for the arms trials, therefore, may account for the greater energy cost for these trials.

In conclusion, the energy cost data for the no arm stepping trials agreed with previous research. The energy cost of stepping with arm use, and stepping without arm use as measured interchangeably by VO_2 ($\text{L}\cdot\text{min}^{-1}$, $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, and METS) was significantly greater than the unsupported

stepping by an average of 3.9%. The small energy cost increase for the arms trials was potentially attributed to the conflicting effects on energy expenditure between upper body support, which to some proportion reduces energy cost, and a greater step depth which increases energy cost. These effects may be expressed mechanically in the equation:

$$\text{Work} = \text{Force} * \text{Distance}$$

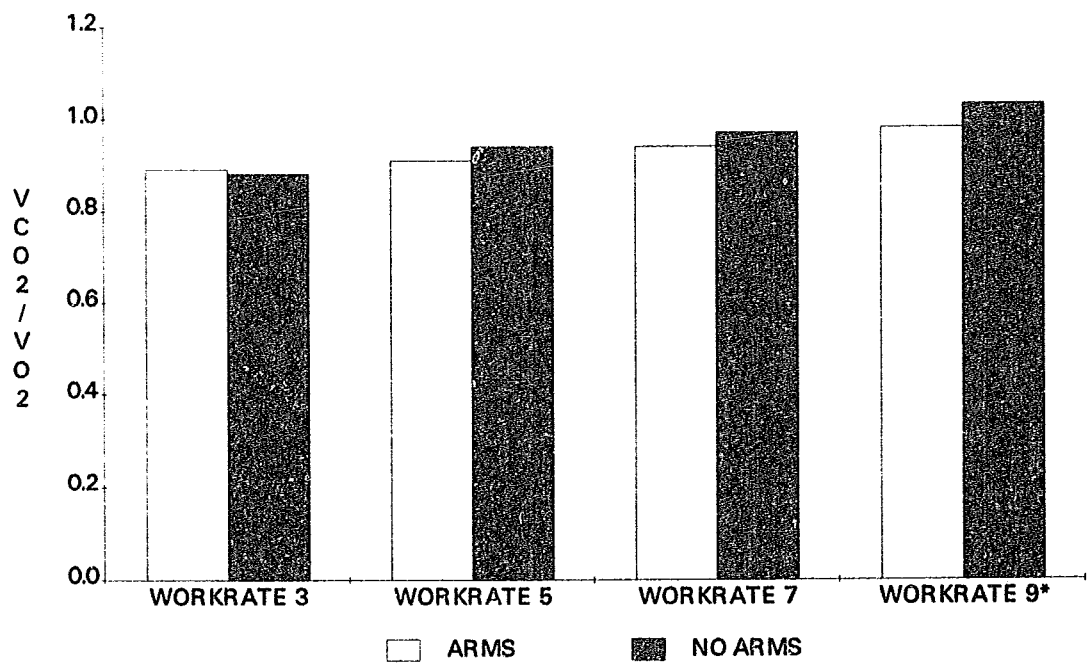
The distance (step depth) was significantly greater for the arms trials, however, the force (body weight) was potentially reduced by the upper body support provided by the UB Sports Fitness Trainer. Therefore, the body weight (force) on the step pedals during the arms trials may have been less than that during the unsupported no arms trials which reduced the total work (energy cost) of the arm trials.

Heart Rate and RPE

The heart rate and the rating of perceived exertion were not statistically different between the arm and no arm use conditions at all workrates. These results indicate that the small increase in energy cost for the arm trials was not accompanied by an increase in heart rate or RPE. This was not expected since as exercise intensity increases both the heart rate (ACSM, 1991 p. 19) and the RPE (ACSM, 1991 p. 71) should linearly increase to evidence the greater energy cost for the arms trials.

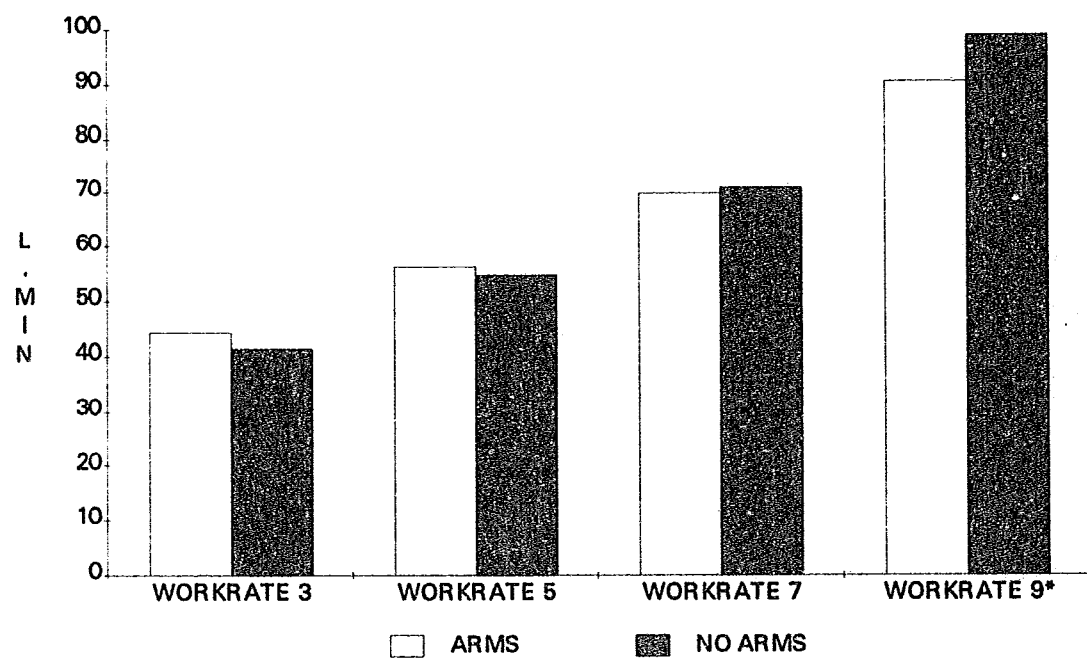
Ventilation and RER

The variables of V_E and RER paralleled the other variables in exhibiting greater values with increasing workrates. These variables, however, both exhibited significant differences between the arms and no arms conditions at workrate 9. At this workrate the V_E (see Figure 1) and the RER (see Figure 2) were both significantly ($p < .05$) higher for the no arms condition. This discrepancy is most likely attributed to the level of the workrate. Workrate 9 was the most physically demanding of the workrates tested, thus causing the majority of subjects to be near maximal exertion.



* No arms significantly ($p < .05$) greater than arms

Figure 1. Mean values of RER with and without arms



* No arms significantly ($p < .05$) greater than arms

Figure 2. Mean values of ventilation with and without arms

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine if there were differences in VO_2 ($L \cdot \text{min}^{-1}$, $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, METS), heart rate, RPE, V_E , RER, and step depth while stepping on the StairMaster with and without arm usage provided by the UB Sports Fitness Trainer.

Twenty-two active male volunteers from the LaCrosse, WI area completed two 20-minute submaximal tests on the StairMaster. The tests consisted of stepping at 4, 5-minute workrates (3, 5, 7, and 9) with and without arm exercise.

Data were obtained for the variables VO_2 ($L \cdot \text{min}^{-1}$, $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, METS), heart rate, RPE, V_E , RER, and step depth each minute throughout the tests. Steady state was determined from the last 2 minutes of each 5-minute workrate. A steady state value was accepted if the oxygen uptake during the last 2 minutes of a workrate did not deviate by more than $1 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$. An average of these 2 minutes were used in the final statistical analysis.

The results were statistically analyzed using a mixed design two-way ANOVA with repeated measures. The .05 level of confidence was used to accept or reject the null

hypotheses. A Tukey post hoc analysis was performed when appropriate.

The variables VO_2 ($L \cdot \text{min}^{-1}$, $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, METS), RER, and step depth during arm usage were significantly ($p < .05$) greater than the no arms condition. However, there were no significant interactions between arms and no arms at various workrates. The average increase in energy cost for the arms condition was 3.9%. Heart rate and RPE were not significantly ($p > .05$) different between arm and no arm usage. For the variables V_E and RER, it was found that the no arms condition was significantly ($p < .05$) greater than the arms condition only at workrate 9. All variables VO_2 ($L \cdot \text{min}^{-1}$, $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, METS), heart rate, RPE, V_E , RER, except step depth between workrates 7 and 9, were significantly ($p < .05$) greater with increasing workrates.

Conclusions

The use of the UB Sports Fitness Trainer while stepping resulted in a small, but significantly greater energy cost than unsupported stepping. This increase in energy cost for the arm trials, however, was also accompanied by a greater step depth which in itself may explain the energy cost increase. Additionally, the higher energy costs did not result in significantly higher heart rate or RPE responses between the arm use and the no arm use conditions.

Based upon these findings future use of the UB Sports Fitness Trainer may be potentially beneficial for those individuals whom presently exercise on the StairMaster 4000PT while using hand support. The results of this study indicated that the use of the UB Sports Fitness Trainer while stepping elicits similar physiological energy expenditure as stepping without hand support. Previous research on the StairMaster comparing hand supported stepping with unsupported stepping revealed an approximate 21% increase in energy expenditure may be obtained. An individual that uses hand support, therefore, can incorporate the UB Sports Fitness Trainer into StairMaster stepping to potentially increase their energy expenditure over that of hand supported stepping.

Recommendations for Future Study

1. A longitudinal study should be conducted to evaluate the effectiveness of the UB Sports Fitness Trainer to improve upper body strength.
2. To determine if proper usage of the UB Sports Fitness Trainer requires a learning factor, future studies should evaluate the energy cost of subjects while using the upper body exercise device on successive days.
3. To further determine the effect of step depth between the arms and no arms conditions, a future

investigation should allow the subjects to use a self-selected stepping rate.

4. To more closely represent the heterogenous population, future studies should incorporate subjects of varying fitness levels with a wider range of ages.

REFERENCES CITED

- American College of Sports Medicine. (1991). Guidelines for exercise testing and prescription (4th ed.). Philadelphia: Lea & Febiger.
- Ang, N., Fahey, B., Klatt, C. J. K., & Williams J. (1993). Comparison of cardiovascular response to treadmill and Stairmaster in pulmonary patients. Medicine and Science in Sports and Exercise, 25(Suppl. 5), S14.
- Auble, T. E., & Schwartz, L. (1991). Physiological effects of exercising with handweights. Sports Medicine, 11, 244-256.
- Auble, T. E., Schwartz, L., & Robertson, R.J. (1987). Aerobic requirements for moving handweights through various ranges of motion while walking. The Physician and Sports Medicine, 15(6), 133-140.
- Ben-Ezra, V., & Verstraete, R. (1988). Stairclimbing: An alternative exercise modality for firefighters. Journal of Occupational Medicine, 30, 103-105.
- Ben-Ezra, V., & Verstraete, R. (1991). Step ergometry: Is it task-specific training? European Journal of Applied Physiology, 63, 261-264.
- Bideaux, A., Wygand, J., Otto, R. M., Helgemore, S., & Kosilla, B. (1991). The metabolic and cardiovascular response to supported stairmaster climbing. Journal of Cardiopulmonary Rehabilitation, 12, 301.
- Butts, N. K. (1994). Effects of body position on energy costs during stairmaster exercise. Unpublished manuscript, University of Wisconsin-LaCrosse, Department of Exercise and Sport Science, LaCrosse.
- Butts, N. K., & Dodge, C. (1993). Daily variability in energy cost of stepping. Unpublished manuscript, University of Wisconsin-LaCrosse, Department of Exercise and Sport Science, LaCrosse.

- Butts, N. K., Dodge, C., & McAlpine, M. (1993). Effect of stepping rate on energy costs during Stairmaster exercise. Medicine and Science in Sports and Exercise, 25, 378-382.
- Butts, N. K., Knox, K. M., & Foley, S. T. (1995). Energy costs of walking on a dual-action treadmill in men and women. Medicine and Science in Sports and Exercise, 27, 1-5.
- Francis, K., & Hoobler, T. (1986). Changes in oxygen consumption associated with treadmill walking and running with light hand-carried weights. Ergonomics, 29(8), 999-1004.
- Holland, G. J., Hoffmann, J. J., Vincent, W., Mayers, M., & Caston, A. (1990). Treadmill vs steptreadmill ergometry. The Physician and Sports Medicine, 18, 79-84.
- Howley, E. T., Colancino, D. L., & Swenson, T. C. (1992). Factors affecting the oxygen cost of stepping on an electronic stepping ergometer. Medicine and Science in Sports and Exercise, 24, 1055-1058.
- Jordan, P. (1992, January/February). Step studies. American Fitness, pp. 40-41.
- Lewis, S., Thompson, P., & Areskog, N. H. (1980). Transfer effects of endurance training to exercise with untrained limbs. European Journal of Applied Physiology, 44, 25-34.
- Loy, S. F., & Holland, G. J. (1990). Fit to compete: Stairclimbing vs. running as a training modality. Randal Wellness Newsletter, Abstract No. 7.
- Luketic, R., Hunter, G. R., & Feinstein, C. (1993). Comparison of stairmaster and treadmill heart rates and oxygen uptakes. Journal of Strength and Conditioning Association, 7(1), 34-38.
- Maud, P. J., Stokes, G. D., & Stokes, L. R. (1990). Stride frequency, perceived exertion, and oxygen cost response to walking with variations in arm swing and hand-held weight. Journal of Cardiopulmonary Rehabilitation, 10, 294-299.

- McConnell, T. R., Foster, C., Conlin, N. C., & Thompson, N. N. (1991). Prediction of functional capacity during treadmill testing: effect of handrail support. Journal of Cardiopulmonary Rehabilitation, 11, 255-260.
- Olson, M. S., Williford, H. N., Blessing, D. L., & Greathouse, R. (1991). The cardiovascular and metabolic effects of bench stepping exercise in females. Medicine and Science in Sports and Exercise, 23, 1311-1318.
- Porcari, J. P., Butts, N. K., Tesch, J., Boge, J., Doronio, D., & Chase, L. (1994). Medicine and Science in Sports and Exercise, 26(Suppl. 5), Abstract No. 580.
- Riddle, S. J., & Orringer, C. E. (1990). Measurement of oxygen consumption and cardiovascular response during exercise on the Stairmaster 4000 PT versus the treadmill. Medicine and Science in Sports and Exercise, 22(Suppl. 2), Abstract No. 385.
- Rosentsweig, J., Verstraete, D., & Basset, G. (1986). Stairclimbing as a training modality for women. Medicine and Science in Sports and Exercise, 18(Suppl. 1), Abstract No. 136.
- SportsTech Services Incorporated, 1104 East 51st Street, Tulsa, Oklahoma 74140, (918) 622-1188.
- StairMaster Incorporated, 12421 Willows Road, N.E., Suite 100, Kirkland, Washington 98034, (800) 635-2936.
- Stamford, B. A., Cuddihee, R. J., Moffatt, R. J., & Rowland, R. (1978). Task specific changes in maximal oxygen uptake resulting from arm versus leg training. Ergonomics, 21, 1-19.
- Stanforth, P., & Stanforth, D. (1993). The effect of adding external weight on the aerobic requirement of bench stepping. Medicine and Science in Sports and Exercise, 25(Suppl. 5), Abstract No. 469.
- Thompson, P. D., Cullinane, E., Lazarus, B., & Carleton, R. A. (1981). Effect of exercise training on the untrained limb exercise performance on men with angina pectoris. The American Journal of Cardiology, 48, 844-850.

- Verstraete, R., & Ben-Ezra, V. (1987). Submaximal cardiovascular response to positive stairclimbing and treadmill walking in cardiac patients. Medicine and Science in Sports and Exercise, 19(Suppl. 2), Abstract No. 340.
- von Duvillard, S. P., & Pivirotto, J. M. (1991). The effect of front handrail and nonhandrail support on treadmill exercise in healthy women. Journal of Cardiopulmonary Rehabilitation, 11, 164-168.
- Wescott, W. L., Greenberger, K., & Anderson, T. (1990). The 20-minute workout: A case study. Randal Wellness Newsletter.

APPENDIX A
ACTIVITY QUESTIONNAIRE

APPENDIX B
INFORMED CONSENT

INFORMED CONSENT

I, _____, would like to volunteer to participate in a project to determine if the use of arm exercise in conjunction with stepping on the StairMaster PT4000 requires greater physiological energy cost. Participation in this project requires that I complete workloads on a stepping machine (StairMaster PT4000) with and without the addition of arm exercise.

This study will require two testing sessions at least 48 hours apart performed on the StairMaster. Four increasing workrates will be used. Each workrate will last five minutes in duration with arm exercise alternating with unsupported stepping as the workrates increase.

During the StairMaster 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 not 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 the test. If any abnormal observations are noted at any time, the testing will be immediately terminated.

All practice and testing sessions will be scheduled at my convenience. The tests and practice sessions will be supervised/conducted by a graduate student enrolled in the Human Performance Graduate Program under the direction of N.K. Butts, Ph.D. This student will explain my results upon completion of the tests.

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 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 without any type of penalty.

Signed: _____
Date: _____

Witness: _____
Date: _____

Appendix C

BORG SCALE OF RATING PERCEIVED EXERTION

Borg Scale of Rating Perceived Exertion

6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very Hard
18	
19	Very, very hard
20	

APPENDIX D
MANUFACTURERS EXERCISE GUIDELINES

SportsTech Services, Inc.

SPORTSTECH'S 'UB' SPORTS FITNESS TRAINER

PROPER EXERCISE TECHNIQUE

To achieve full exercise benefits and to prevent injury, proper technique is of absolute importance.

- * While stairclimbing, stand erect and move 'UB' ARM BARS back and forth using a comfortable range of motion.
- * Coordinate your upper body exercise pace with your stairclimbing pace.
- * Upper body conditioning combined with stairclimbing is an intense exercise.
- * Maintain an upright posture and alter hand placement on ARM BARS to isolate different muscle groups.

PROPER OPERATION

- * Adjust resistance by turning knob on side of 'UB'.
- * We recommend setting 'UB' at light resistance. Work up to higher levels.
- * Start Exercise.
- * Move ARM BARS in conjunction with leg movement.
- * Electronic information, average calorie burn, speed, number of reps/steps, and timer are automatic.

1104 EAST 51ST ST. TULSA, OK 74140 918 622-1188