

ABSTRACT

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Untrained college aged females (n = 45) were studied to determine if 7 wk rebounding and jogging programs would elicit similar cardiovascular training effects. The 13 joggers, 19 rebounders, and 13 controls who ranged in age from 19 - 32 yr volunteered to participate. The joggers and rebounders trained for 4 days a wk for 30 min each session. A pre (T₁) and post (T₂) Modified Astrand Treadmill test was administered to all Ss. Each was assigned a target HR based on 75% of the max HR obtained on the initial TM test. HR's were checked 3 times during each exercise session and averaged 78% for the rebounders and 82% for the joggers during the 7 wks. The following variables were analyzed using an ANOVA with Repeated Measures; body wt, submax RPE, max RPE, TM run time, max HR, VE max, RER, and VO₂ max in L·min⁻¹ and ml·kg·min⁻¹. A Scheffé post hoc was used to determine areas of sig. No sig changes (p > .05) were seen from T₁ to T₂ for the following variables: body wt, max RPE, VE max, RER, and VO₂ max. A sig increase (p < .01) in max HR was seen in joggers and rebounders. A sig decrease (p < .01) was seen in submax RPE for the joggers pre to post test. A sig increase (p < .01) was seen for all groups combined in TM run time from T₁ to T₂. Pre test controls had sig higher (p < .01) VE max values than the experimental groups. Control Ss showed no sig changes (p > .05) in any variable from T₁ to T₂. It was concluded that rebounding and jogging for 7 wks did not elicit a CV training effect in this investigation.

CARDIOVASCULAR EFFECTS:
REBOUNDED VERSUS JOGGING
ON UNTRAINED COLLEGE FEMALES

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to
The Graduate Faculty
University of Wisconsin - La Crosse

In Partial Fulfillment
of the Requirements for the
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by
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Obrigada para sua paciência e amor. Eu te amo para sua compreensão. Um beijo.

Baiana

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CHAPTER I
INTRODUCTION

The goal of an exercise program is to develop fitness. Fitness involves increasing flexibility, strength, and above all, cardiovascular endurance. For those involved in delivering exercise to the consumer, one of the biggest obstacles to overcome is lack of compliance. Boredom, injuries, inconvenience, and expense are some factors that keep people from enduring exercise. More variety in the types of exercises offered through fitness programs may decrease the number of drop-outs. Compliance would, therefore, increase. In order to have this variety, more types of exercises must be researched to determine their effectiveness for developing strength, cardiovascular endurance, and flexibility. Consumers should have the assurance that the activity they engage in has been researched and demonstrated to improve fitness.

One form of exercise that has gained recent popularity is called rebounding. It is a form of trampolining done on a much smaller device than a full bed trampoline. A rebounder, the piece of equipment used to rebound, consists of a firm mat, 36 inches in diameter, attached to a chrome frame by strong springs. The frame stands six to nine inches tall. The mat is parallel to the ground. The

rebounder was first introduced in 1975 and has since been produced by more than 25 manufacturers (Walker & Angelo, 1981). Rebounders now come in many different shapes for a variety of prices.

"The science of bouncing up and down in a vertical plane without performing tricks is reboundology" (Walker & Angelo, 1981, p. 13). Some movements on the rebounder resemble dance movements. Other movements resemble calisthenics or running. The rebounder gives added spring to allow a person more capacity to vary their movements. Instead of hitting a hard floor, the person rebounding hits a soft but firm mat that gives under their weight and bounces them back up into the air. "The bounce of rebounding provides you with the freedom of moving, turning, twisting, kicking, and stretching the body without pain and performed at your own pace" (Walker & Angelo, 1981, p. 6). Proponents of rebounding claim that it is an exercise done against gravity. Adding acceleration and deceleration to the gravitational pull of the earth, according to Carter (1979), strengthens the wall of every cell in the body.

"The guru of reboundology is Albert E. Carter, who heads a recently formed organization called 'The National Institute of Reboundology and Health', Edmonds, Wash." (Lamb, 1981, p. B6). He has written a book entitled The Miracles of Rebound Exercise and has done much to promote its use. Rebounding is an attractive form of exercise

because of its versatility. Rebounding can be done inside or outside, in any kind of weather, at any time of day, with only one piece of equipment, and in any kind of clothing that is comfortable. These features have added to the popularity of this form of exercise.

Purpose of the Study

This study was designed to compare the effects of a rebounding program versus a jogging program. The purpose was to determine if rebounding could generate the same level of cardiovascular fitness as jogging.

Need for the Study

The need for this study stemmed from the lack of research literature available about rebounding. Consumers are entitled to information about rebounding that has been researched and verified. Samples of statements published about rebounding border on the miraculous.

"Rebound exercise is a method of stimulating every cell of the body simultaneously by increasing the G force applied to every cell" (Carter, 1979, p. 80). "It is more beneficial physiologically, therapeutically, and for its protective effects against degenerative diseases, especially cancer, than any other forms of motion in the workplace, in recreational pursuits, or in exercising simply for the care of your body" (Walker & Angelo, 1981, p. 55). There have

been no research articles published that relate rebounding to the prevention of cancer or degenerative diseases. "In place running on your rebounding device for uninterrupted periods in excess of five minutes would steadily build up cardiopulmonary endurance and ensure saturation of the blood with oxygen molecules" (Walker & Angelo, 1981, p. 24). The American College of Sports Medicine (1980) recommends at least 20 minutes of exercise, three times a week to receive cardiovascular benefit.

Research studies done with rebounding are sparse. Katch and Villanacci (1981) studied energy cost of rebound-running. White (1980) observed oxygen consumption and weight changes in a group of overweight women while jogging, biking, and rebounding. Gabbard (1980) tested eight and nine year olds before and after six weeks of regular trampolining. He measured improvement through time on a half mile run.

In contrast, many articles have been published on the benefits of jogging (Saltin, Blomqvist, Mitchell, Johnson, Wildenthal, & Chapman, 1968; Wilmore, Davis, O'Brien, Vodak, Walder, & Amsterdam, 1980; Pollock, Wilmore, & Fox, 1978; Ekblom, Astrand, Saltin, Stenborg, & Wallstrom, 1968). These benefits are reflected by changes in maximal and submaximal oxygen consumptions, pulmonary function tests, heart rate responses, cardiac output measurements, and in arterial venous oxygen differences. Documentation

regarding the effects of rebounding on these same parameters is needed.

An additional factor contributing to the need for this study was the lack of compliance seen in exercise programs. The rebounder offers another means to exercise and variety may increase the chance of keeping at least one more person interested and involved in a fitness program.

Lastly, the research abounds with studies on men regarding jogging and fitness (Wilmore et al., 1980; Gettman, Pollock, Durstine, Ward, Ayres, & Linnerud, 1976; Durnin, Brockway, & Whitcher, 1960; Wilmore, Royce, Girandola, Katch, & Katch, 1970; Pearn, 1980; Fox, Bartels, Billings, Mathews, Bason, & Webb, 1973; Ekblom et al., 1968). Women have not been as widely studied (Edwards, 1974; Kearney, Stull, Ewing, & Strein, 1976; Cunningham & Hill, 1975; Eisenman & Golding, 1974).

Hypothesis

The null hypothesis for this study reads as follows; there is no significant difference between cardiovascular changes obtained after seven weeks of training on a rebounder and after seven weeks of training through jogging.

Assumptions

It was assumed that the experimental subjects for this study refrained from any other regular program involving

aerobic activity during the seven weeks they took part in either the jogging or the rebounding portions. It was also assumed that the control group refrained from any type of regular aerobic activity during the seven weeks between their exercise tests.

Delimitations

This study was delimited to beginning on March 22 and ending on May 6. Forty-five college aged women volunteers were used as subjects. The training period was delimited to 30 minute exercise sessions, four days a week. Maximal graded exercise tests were administered before and after training. The parameters measured included maximal oxygen consumption, maximal ventilatory volume, time on the treadmill, maximal heart rate, respiratory exchange ratio, and perceived exertion.

Limitations

The training period of the study was limited to seven weeks. A longer period may have provided extra time to see greater changes cardiovascularly.

Volunteers enrolled in a PE 100 section of jogging and fitness for the second quarter of the second semester at the University of Wisconsin - La Crosse were used as subjects rather than randomly selected individuals. Volunteers from other PE classes were used as controls.

Due to the time constraints of the class, the subjects were deprived of an introductory visit to the laboratory. The pre-test was their first experience with wearing a mouthpiece, headgear, and electrodes and with walking on the treadmill. The awkwardness of running for the first time on a treadmill with the bulky measuring instruments may have caused some individuals to stop before they reached their true maximum.

Music was available for the rebounders during their exercise sessions. Joggers were allowed to jog outside in good weather and, therefore, lacked that motivating factor.

Due to the newness of rebounding, the rebounders were exposed to interested and encouraging passers-by. The joggers did not have this added factor.

Since the speed and running styles of the joggers varied, most jogged alone or with one other person. Self motivation played an important role in their training. The rebounders jumped with at least two and sometimes as many as four other people. Group motivation in addition to self motivation was apparent in their training.

The rapid increase in distance covered and time spent jogging as opposed to time spent walking in the seven week period led to overuse and stress related injuries that caused a reduction in intensity or duration for some of the exercise sessions. The joggers were

affected by this more than the rebounders.

Definitions of Terms

Maximal Oxygen Consumption ($\dot{V}O_2$ max) - the maximal amount of oxygen consumed and utilized by the muscles during exercise at a person's volitional physiological maximum during treadmill running. This was expressed in absolute values as liters per minute ($L \cdot \text{min}^{-1}$), or in relative terms as milliliters per kilogram of body weight per minute ($\text{ml} \cdot \text{kg} \cdot \text{min}^{-1}$).

Maximal Ventilatory Volume ($\dot{V}E$ max) - the amount of air expired for a full minute by a person exercising at their volitional physiological maximum during treadmill running.

Rebounder - an exercise device consisting of a firmly constructed, flexible mat with a diameter of 36 inches. The mat is attached by stiff springs to a sturdy chrome frame and is parallel to the ground. The frame varies in shape from circular to square to polygonal, and has from four to eight legs. The legs stand six to nine inches high. The rebounders used in this study were distributed by Olympus Distributing Corporation and were called Sundancers.

Rebounding - bouncing in a vertical manner that is anti-gravity. It can range from a gentle bounce to vigorous running in place and jumping. It does not include gymnastic tricks or extremely high jumping.

Jogging - a non-competitive running motion performed at a slow pace.

Experimental Group - a group of subjects who experienced the influence of the independent variable in this research. The independent variable in this study was seven weeks of training on a rebounder or through jogging at a prescribed level.

Control Group - a group of subjects who did not experience the influence of the independent variable.

CHAPTER II
REVIEW OF RELATED LITERATURE

Introduction

The following chapter has been divided into major sections on topics related to this investigation. A discussion of the definition, measurement, development, and maintenance of cardiovascular fitness leads to two sections dealing with the advantages and disadvantages of both jogging and rebounding as cardiovascular training modalities.

Cardiovascular Fitness

Definition

Camaione and Sinatra (1981, p. 621) quoting the AAHPERD definition, defined physical fitness as a "multifaceted continuum measuring the quality of health ranging from death and diseases to the optimal functional abilities of various physical aspects of life". The four components of physical fitness included body composition, flexibility, muscular fitness, and cardiorespiratory fitness (Camaione & Sinatra, 1981). Camaione and Sinatra (1981, p. 621) further defined cardiovascular fitness as "the ability of the circulatory and respiratory systems to deliver oxygen and nutrients to the body cells and carry away carbon dioxide and waste products".

Hollmann, Rost, and Liesen (1980) discussed five components of physical fitness. These included speed, endurance strength, flexibility, and co-ordination. They stated that there are eight forms of endurance, and ranked general aerobic endurance as the most important. "Improvement of 'general aerobic endurance' by means of endurance training comes about via an increase in cardiopulmonary and metabolic efficiency and economization of all circulatory and respiratory processes" (Hollmann et al., 1980, p.9).

Astrand and Rodahl (1977) divided physical performance into five different functions including muscular strength, joint mobility, coordination, will to win, and endurance. Level of endurance was based on the capacity of the oxygen transport organs. The actions of those organs effect pulmonary ventilation, oxygen binding capacity of the blood, cardiac output, cardiac pumping capacity, arterial - venous oxygen difference, venous return, and fluid balance (Astrand & Rodahl, 1977). These measurable physiological parameters discussed by Astrand and Rodahl (1977) determine the effectiveness of cardiorespiratory functions.

There is general agreement that fitness involves several aspects of conditioning; the most important being cardiorespiratory conditioning. A healthy heart, a healthy set of lungs, and a healthy circulatory system comprise the largest component of a healthy body, which is the cardiorespiratory system. Strengthening and training directed at

this system has the potential for increasing the work capacity and recreational capacity of the total population.

Measurement

Many tests are now available to measure the fitness level of the heart and lungs. These tests involve exercises that push a person beyond their usual exertion level. The tests are administered using different exercise modalities such as bike ergometers, steps, or motor driven treadmills. Fitness tests may be either maximal or submaximal tests.

Maximal exercise testing involves exercising subjects to their physiological maximum while certain physiological parameters are measured. The most meaningful parameter measured is called maximal oxygen consumption ($\dot{V}O_2$ max). "Maximal oxygen consumption ($\dot{V}O_2$ max) is generally accepted as the best physiological index of cardiorespiratory (CR) endurance performance, i.e., events lasting approximately 3 to 30 min." (Stewart, Williams, & Gutin, 1977, p. 413).

If a person is subjected to progressively increasing workloads, there is a linear relation between workload and oxygen uptake until the maximal oxygen uptake is reached...Maximal oxygen uptake is the greatest amount of oxygen a person can take in during physical work and is a measure of his maximal capacity to transport oxygen to the tissues of the body...Maximal oxygen uptake normalized for body weight is the most useful single measurement characterizing the functional capacity of the oxygen transport system (cardiovascular and pulmonary systems) (Mitchell & Blomqvist, 1971, p.p. 1018 - 1021).

A high $\dot{V}O_2$ max value represents a high level of cardiovascular fitness. Values for $\dot{V}O_2$ max are available for the unfit, sedentary individual as well as the top, world class

athlete. It can be measured in absolute values as liters per minute ($L \cdot \text{min}^{-1}$), or in relative values as milliliters per kilogram of body weight per minute ($\text{ml} \cdot \text{kg} \cdot \text{min}^{-1}$). A value of $32 \text{ ml} \cdot \text{kg} \cdot \text{min}^{-1}$ represents a very low fitness level for females (Astrand & Rodahl, 1977). A $\dot{V}O_2$ max of $43 \text{ ml} \cdot \text{kg} \cdot \text{min}^{-1}$ is considered the lowest value that represents fitness and women with values below 43 are recognized as untrained (Astrand & Rodahl, 1977). Women cross country skiers have been reported to have $\dot{V}O_2$ max values as high as $72 \text{ ml} \cdot \text{kg} \cdot \text{min}^{-1}$. The more fit a person becomes, the more oxygen that person will utilize. This is the core to many research studies today. The mechanisms that help to increase utilization are being investigated.

Direct measurement of $\dot{V}O_2$ max is possible only via a maximal exercise test. Requirements for a good maximal exercise test include using large muscle groups, having a workload that is reproducible and measurable, having test conditions that are reproducible, using a test that can be tolerated by all persons involved, and having uniform skill requirements to perform the test (Astrand & Rodahl, 1977).

The treadmill is the most popular modality used to test individuals. Many testing protocols have been developed. Taylor, Buskirk, and Henschel (1955) utilized a protocol with a constant speed and an increase of 2.5% grade on each proceeding visit to their lab. The big drawback to this procedure was the necessity of having each subject tested

on three to four consecutive days till $\dot{V}O_2$ max was reached. Mitchell, Sproule, and Chapman (1958) performed a similar treadmill test but completed the protocol in one day. Each workload increment was separated by only ten minutes of rest.

Pollock, Bohannon, Cooper, Ayres, Ward, White, and Linnerud (1976) compared four popular treadmill protocols using 51 healthy males. All four tests were continuous tests in that no rest periods occurred between stages. The Balke, Bruce, and Ellestad protocols are essentially walking protocols and resulted in average $\dot{V}O_2$ max values of 39.4 ± 5.9 ml·kg·min⁻¹, 40.0 ± 7.2 ml·kg·min⁻¹, and 40.0 ± 7.1 ml·kg·min⁻¹, respectively. The Modified Astrand is a running protocol and resulted in an average $\dot{V}O_2$ max value of 41.8 ± 6.7 ml·kg·min⁻¹. The Modified Astrand also showed slightly higher maximal heart rate values as well as the shortest test completion time. Due to the higher values for heart rate and $\dot{V}O_2$ obtained at early stages with the Modified Astrand protocol, it was not recommended for screening persons suspected of having coronary artery disease (Pollock et al., 1976). It was, however, shown to be a good tool for assessing the fitness levels of healthy individuals.

Submaximal exercise tests are also utilized in measuring cardiovascular efficiency. A submaximal parameter such as heart rate is used to predict $\dot{V}O_2$ max values (Astrand & Rhyming, 1954).

Other variables considered when measuring cardiovascular

fitness include resting heart rate, maximal heart rate, recovery heart rate, cardiac rhythm stability, blood pressure response, ventilatory capacity, subjective feelings at given test stages, serum levels of cholesterol and triglycerides, and cardiac output. Oxygen consumption measurements are augmented by each additional variable that can be measured with every exercise test administered.

Development and Maintenance

Intensity. "A central question is 'how much' or rather 'how little' exercise is necessary to stimulate the cardiovascular system" (Edwards, 1974, p. 14). The intensity of training needed to improve cardiovascular fitness has been widely researched (Edwards, 1974; Kilbom & Astrand, 1978; Durnin, Brockway, & Whitcher, 1960; Cunningham & Hill, 1975; Kearney, Stull, Ewing, & Strein, 1976; Sharkey & Holleman, 1966; Shephard, 1968; Rosentswieg & Burrhus, 1975; Sharkey, 1970). "A quantitative distinction is needed between a training overload which supplies maximal conditioning, and that which provides an exercise minimum concomitant with health" (Edwards, 1974, p. 18).

Karvonen, Kentala, and Mustala (1957) determined a formula for assurance of proper training intensity. They concluded that to achieve a reduction in exercise heart rate at submaximal levels, the training heart rate should be equivalent to resting heart rate plus 60% of heart rate reserve (heart rate reserve = maximal heart rate minus

resting heart rate).

Durnin et al. (1960) trained 44 males for ten days. The subjects walked zero, ten, twenty, and thirty kilometers per day at a heart rate of 120 to 130. This was an example of a lower intensity exercise done for longer duration. They reported improvement of pulmonary ventilation and oxygen consumption in the 20 kilometer group only. They suggested that the exercise for the 30 kilometer group was too severe for their initial fitness level.

Sharkey and Holleman (1967) trained 16 college men at 120, 150, and 180 heart beats per minute. Their results showed that the 180 group improved significantly. Improvement in the 150 group was less but still significant. No improvement was seen in the group that trained at 120. They suggested that the optimal training level lies somewhere between 150 beats per minute and maximal exertion.

Shephard (1968) concluded from his study of 39 sedentary individuals on various training programs, that the results of exercise depend on the intensity of effort and the initial fitness of the participant. His subjects had an average predicted $\dot{V}O_2$ max of $43.3 \text{ ml} \cdot \text{kg} \cdot \text{min}^{-1}$. The three intensities he used were 39%, 75%, and 96% of maximal aerobic power. The higher the intensity the more cardiovascularly fit his subjects became.

In 1970 Sharkey conducted a training study also utilizing heart rate to measure intensity. He assigned individuals

to three intensity groups; 130, 150, and 170 beats per minute, but held constant the total work performed. He found no significant cardiorespiratory changes after training in any group. He did, however, see greater improvement in subjects with lower initial fitness levels.

Kilbom and Astrand (1978) tested 13 females. Their subjects biked at 70% of their maximal aerobic power, three times a week for seven weeks. Sessions lasted 30 minutes and training was intermittent. All subjects showed an increase in cardiovascular fitness.

Edwards (1974) trained two groups of females on a treadmill at heart rates of 125 and 145. These rates corresponded to an average of 63.7% and 75.2% of maximal heart rate, respectively. She found significant increases in $\dot{V}O_2$ max from pre to post training in both groups.

Rosentswieg and Burrhus (1974) found no significant improvement in oxygen consumption after training a group of females at 120, 140, and 160 beats per minute for four weeks. They, like Sharkey (1970), held total work constant. Therefore, frequency and duration of work were varied.

Kearney et al. (1976) saw significant improvement in 27 women trained at 50% and 65% of Karvonen's heart rate reserve. They trained three times a week for nine weeks. Greater increases of significance in $\dot{V}O_2$ max were seen in the group that trained at 65%.

As a result of numerous investigations, the American

College of Sports Medicine has established guidelines for the prescription of exercise intensity. They stated that "during conditioning sessions peak efforts should not exceed 90% of functional capacity and the average intensity during a conditioning session should approximate 70%" (ACSM, 1975, p. 34).

Frequency. Frequency relates to the number of exercise sessions completed per week during a training program. The American College of Sports Medicine (1975) recommended at least three to five sessions of exercise per week as being optimal for cardiovascular improvement. Studies regarding this parameter have produced conflicting results.

Kilbom (1971) saw no significant increase in $\dot{V}O_2$ max in women subjects who walked three days per week. Shephard (1968) ranked intensity and duration as being more important than frequency of exercise.

Gettman, Pollock, Durstine, Ward, Ayres, and Linnerud (1976) saw significant improvements in $\dot{V}O_2$ max treadmill performance time, and maximal pulmonary ventilation in direct proportion to the number of days exercised per week. This study was done on county prisoners who exercised one, three, and five days. Pollock, Gettman, Milesis, Bah, Durstine, and Johnson (1977) found similar results. Sharkey (1970) saw positive adaptation at a workout frequency of three times per week.

The importance of frequency should be viewed in

perspective with intensity. As seen in the study by Gettman et al. (1976), subjects working at 90% maximal aerobic power improved from just exercising one day per week. Their intensity was high and their frequency was low. Kilbom (1971) had his subjects working at 50% of maximum, three days per week and produced no significant change in oxygen uptake. Their intensity was low and their frequency was higher. If the intensity is high enough, the positive changes occur in direct proportion to the number of exercise sessions (Gettman et al., 1976). If the number of exercise sessions are limited, the intensity must be raised.

Duration. "In the present state of inadequate knowledge, a quarter hour of relatively high intensity exertion (using the appropriate 'heart rate margin') is considered a desirable minimum" (Fox, 1974, p. 4D - 17). The American College of Sports Medicine (1975) agreed that an exercise response may be obtained through just 15 minutes of properly intensified activity. However, they recommended 20 to 30 minutes for a person just beginning. Once conditioning begins the ACSM advised increasing the duration to 20 to 45 minutes per session.

Roskamm (1967) reported cardiorespiratory improvements in women exercising for 30 minutes daily. Edwards (1974) observed an increase in cardiovascular fitness after 15 minute training sessions once a day. Pollock et al. (1977) trained subjects for 15, 30, and 45 minutes per

exercise session. They observed improvement in direct proportion to duration.

In summary, the amount of exercise needed to elicit a positive cardiorespiratory response in a normal, healthy individual appears to be: intensity of 60% to 90% of functional capacity or 60% to 90% of heart rate reserve; frequency of three to five days per week; and duration of 15 to 45 minutes per session.

Rebounding

Introduction

Rebounding is defined by Walker (1981) as "aerobic movements performed on a device that looks like a small trampoline" (p. 91). Rebounding movements range from a low level, slow walk in place to vigorous running, jumping, and twisting movements utilizing arm motions and large leg muscle groups. It is recognized as being antigravity, due to the vertical movements against gravity during an upward bounce. The device used to rebound comes in many shapes and sizes and is sold under the guise of many catchy names. The device used in this study was called the Sundancer and was distributed by Olympus Distributing Corporation from Utah. This type of modality is gaining widespread popularity as a means of "getting in shape". It is viewed as an exercise that can be accomplished in the home with minimal need for specialized equipment.

Research on Rebounding

Very little published research is available regarding the effects of a rebounding program. White (1980) trained 60 overweight women for ten weeks on rebounders, bicycles, and through running. They exercised four days per week for 30 minutes a session. He reported increases in $\dot{V}O_2$ max in all three groups and decreases in percent body fat in all three groups. He concluded that rebounding was not significantly different than running or biking.

Katch and Villanacci (1981) studied the energy cost of rebound - running. They measured $\dot{V}O_2$ max, kilocalories (Kcals), and heart rate (HR) in five women and seven men while rebound - running at 54 to 69 steps per minute. They reported an average oxygen consumption of $17.85 \text{ ml} \cdot \text{kg} \cdot \text{min}^{-1}$, placing rebound - running in a moderately exertive category. The average amount of Kcals expended per kilogram per minute was reported as 0.086. With this type of Kcal expenditure they concluded that the reported loss of percent body fat in White's study (1980) would have been impossible. Twelve hundred minutes of exercise using up 0.086 Kcals per kilogram per minute would result in the average use of 9600 Kcals. To drop as much weight as White (1980) reported, the subjects would have needed to burn up 94,153 Kcals. Eighty-four thousand Kcals were not accounted for. White (1980) reported to have controlled diet and any additional exercise during his study, in a personal communication with

Katch and Villanacci (1981). Katch and Villanacci (1981) reported an average heart rate of only 115.8 beats per minute during their study.

A related investigation by Gabbard (1980) was done on eight and nine year olds. The subjects performed aerobic movements on a four by eight foot trampoline or ran endurance runs. The activity was done only twice a week for seven minutes a session. Improvement was measured via performance on a half mile run. No significant improvement was seen.

Despite the lack of published research articles, such "scientific support" is noted in advertisement and promotion for rebounders. "Rebound exercise is a method of stimulating every cell of the body simultaneously by increasing the G force applied to every cell" (Carter, 1979, p. 80). Miraculous claims have been published about rebounding in regards to cellular oxygenation, lymphatic cleansing, mental stress, aging, coordination, vision, and physiologic functioning. "In place running on your rebounding device for uninterrupted periods in excess of five minutes would steadily build up cardiopulmonary endurance and insure saturation of the blood with oxygen molecules" (Walker & Angelo, 1981, p. 24).

Carter (1979) claimed that rebound exercise will help many aspects of a person's life (see Table 1). Of rebounding's effect on vision he stated, "Improved vision comes about when the millions of cells in the eyes and the muscles

controlling the eyes are individually impressed to do a better job because of increased environmental stress" (Carter, 1979, p. 119).

Table 1

Aspects of Life Improved by Rebounding

-
-
- 1) Balance
 - 2) Tactal and kinesthetic awareness
 - 3) Positive body image
 - 4) Coordination
 - 5) Spacial awareness
 - 6) Timing
 - 7) Rhythm
 - 8) Self confidence
 - 9) Attention span
 - 10) Behavior
 - 11) Problem solving and positive learning skills
 - 12) Visualization/visual memory
 - 13) Voluntary muscle action
 - 14) Breathing habits
 - 15) Endurance
 - 16) Caloric burn
 - 17) Lymphatic circulation
 - 18) Self esteem
-

Carter, 1979, p. 124

In his book, Carter referred to Dr. James White who stated that rebounding is less harmful to the skeletal system than jogging secondary to the impact force being absorbed over a longer period of time (Carter, 1979). Carter also emphasizes the effect of rebounding on the lymph system. "The natural body fluid pumps are activated by any change in pressure, whether internal or atmospheric, and by

any change in the G force. The most effective way to activate the natural body fluid pumps is by rebounding vertically" (Carter, 1979, p. 102).

Quotes and claims were numerous when reviewing literature published about rebounding. Experimental evidence was lacking.

Jogging

Introduction

To jog is defined by Webster's (1981) as, "to cause to move or work, as an engine;...to pace, as a horse, at a regular gait;...to move at a slow trot, as a form of mild exercise" (p. 519). This simple, easily accomplished form of exercise, has gained the following of millions in the past ten years. People have adopted it as a form of exercise, designed clothes for it, developed and sold shoes for it, established sporting events encompassing it, studied it, sold books about it, and made millions from it. It is well researched and documented as one of the best forms of exercise to improve fitness (Daniels, Yarbrough, & Foster, 1978; Kearney et al., 1976; Ekblom, Astrand, Saltin, Stenberg, & Wallstrom, 1968; Eisenman & Golding, 1975; Wilmore, Royce, Girandola, Katch, & Katch, 1970; Wilmore, Davis, O'Brien, Vodak, Walder, & Amsterdam, 1980; Orenstein, Franklin, Doershuk, Hellerstein, Germann, Horowitz, & Stern,* 1981).

Zohman (1978) explained jogging as "the slowest, easiest form of running. It propels you forward somewhat faster than walking, and adds an up and down or antigravity component (Zohman, 1978, p. 3). She explained that a runner spends more time in the air with his feet off the ground than a jogger. Zohman (1978) compared jogging and running by the speed at which they are performed. Five to eight point five miles per hour (mph) was classified as jogging. Eight point five to 15.7 mph was called running. Often in the literature, the terms are intermixed. For the following discussion both definitions will be used.

Research on Jogging

Karvonen et al. (1957) investigated heart rate response to four weeks of running, 30 minutes a day, four to five days a week. Six male medical students served as subjects. Training intensity was held constant by working heart rate. They observed a decrease in resting heart rate as well as a need to increase running speed to achieve the same working heart rate as training progressed. They noted a critical limit at 60% of the pulse range. Below this level, no training effects on heart rate occurred.

Shephard (1968) studied 39 sedentary males before and after training at varying intensity, frequency, and duration. The intensities were three point five miles per hour, zero percent grade; five miles per hour, one percent grade; and five miles per hour, six percent grade. They exercised

five, ten, and twenty minutes per session, one, three, and five times per week. He concluded that training effects, notably increases in $\dot{V}O_2$ max, were found more readily in individuals who were less fit when beginning an exercise program. He also reported greater improvement as intensity, frequency, and duration increased.

Ekblom et al. (1968) studied ten males over 16 weeks of cross - country running. They noted an increase in $\dot{V}O_2$ max, a decrease in submaximal heart rates, an increase in stroke volume, an increase in maximal cardiac output, an increase in maximal arterial - venous oxygen difference, a decrease in submaximal cardiac output, and no change in maximal heart rate values.

Wilmore et al. (1970) investigated the effect of ten weeks of jogging, 12 and 24 minutes a day, three days a week on 55 males aged 17 to 59. They reported significant increases in vital capacity and $\dot{V}O_2$ max. They saw significant decreases in resting heart rates, resting diastolic and systolic blood pressures, and maximal heart rates.

Daniels et al. (1978) trained two groups of men over eight weeks. Group A was composed of 12 untrained physical education students and group B consisted of 15 recreational runners. Every two weeks the distance covered was increased till the subjects were running six point four kilometers, five days a week. Group A increased their $\dot{V}O_2$ max during the first four weeks, then leveled off. Performance as measured by time

on 805 and 3218 meter runs, improved throughout the eight weeks. No $\dot{V}O_2$ max changes of significance were seen in group B. Group B also improved running performance throughout the experiment. These results illustrate the effect that initial levels of fitness have on cardiovascular changes seen with training.

Wilmore et al. (1980) compared physiological changes seen as a result of 20 weeks of bicycling, tennis, and jogging in 38 sedentary males. They trained three days a week for 30 minutes a day. $\dot{V}O_2$ max and maximal ventilation increased significantly for the bikers and joggers. The tennis group showed nonsignificant increases. Resting blood pressure did not change for any group.

The previous studies reviewed utilized men as subjects. The amount of research done on women has been less abundant. "Statistics tell us that the number of female athletes participating in high school and collegiate athletic events has more than doubled in the last five years" (Hunter, 1981, p. 48). The opinions of the public regarding women in sports have returned to those of early historical times. The Spartan society encouraged activity for women and "believed that well - conditioned females made better childbearers" (Hunter, 1981, p. 48). Women participated in gymnastics, tennis, basketball, boating, bicycling, and golf in the 1800's. Between 1920 and 1950 women lost the freedom to participate in a wide variety of sports due to societys

view of it being harmful, psychologically damaging, and unladylike (Hunter, 1981). Gradually since 1950 this view has been challenged and increasing knowledge of female physiology has put women into the realm of athletics once again. The need still exists for studies involving the response of women to various forms of physical activity.

Edwards (1974) trained 12 females daily for four weeks. She observed significant increases in treadmill time and $\dot{V}O_2$ max from pre to post training.

Rosentswieg and Burrhus (1975) trained 28 female volunteers ages 18 to 24 for four weeks. Groups one, two, and three trained three days per week for 15 minutes a day at heart rates of 120, 140, and 160, respectively. Group four trained at a heart rate of 140, and group five trained at a heart rate of 160. Groups four and five worked to the point of having the same mean workload as group one. These investigators saw no improvement in $\dot{V}O_2$ max after training in any training group.

Eisenman and Golding (1975) tested eight girls, ages 12 to 13, and eight women, ages 18 to 24, before and after 14 weeks of bench stepping and jogging. The subjects trained three days a week for 30 minutes a day and were able to jog an average of one point eight miles and stepped 150 times by the end of the training period. Both groups showed significant improvement in measurements of $\dot{V}O_2$ max and maximal pulmonary ventilation.

Cunningham and Hill (1975) trained 17 women on a jogging program for nine weeks. They noted a significant increase in $\dot{V}O_2$ max and in stroke volume. Little change was seen in arterial - venous oxygen difference. Six subjects continued to train for a total of 61 weeks. After final testing these six showed lowered gains in $\dot{V}O_2$ max and a slight lowering of stroke volume. Significant increases were seen, however, in arterial - venous oxygen differences after the 61 weeks.

Kearney et al. (1976) observed an increase in $\dot{V}O_2$ max and a decrease in maximal pulmonary ventilation after training 27 sedentary women three days a week for nine weeks. The running was performed at 50% and 65% of Karvonen's heart rate reserve.

Summary

The three components for developing and maintaining cardiovascular fitness are intensity, frequency, and duration of exercise. Guidelines for minimal exercise parameters from the American College of Sports Medicine are 20 to 30 minutes of exercise, three to five days a week, at an intensity of 60% to 90% of heart rate reserve.

It is generally accepted that measurement of cardiovascular fitness is best accomplished through measurement of $\dot{V}O_2$ max. Many tests are available for this purpose, notably graded exercise tests performed on treadmills or bike ergometers.

Jogging has been widely researched and proven to be an effective form of exercise for improving cardiopulmonary fitness. A new form of exercise called rebounding has not been as widely researched. The claims published in advertisements and books about rebounders and rebounding, boast support from "scientific findings". The fact that "scientific findings" are scarce supports the need for a study involving the measurement of benefits obtained from this new form of exercise.

CHAPTER III

METHODS

Introduction

This chapter details the methods utilized during this investigation. It is divided into six sections. The first section outlines the parameters used to select subjects. Section two details the initial testing procedure. The training program for both joggers and rebounders is presented in section three. Section four gives a brief explanation regarding the parameters surrounding the control group. The fifth section summarizes the final testing procedures. Lastly, the statistical analysis chosen for determination of significance is explained in section six.

Selection of Subjects

Forty - five untrained female volunteers were the subjects selected for this study. Their ages ranged from 19 to 31 years. Most of the volunteers were enrolled in physical education classes at the University of Wisconsin - LaCrosse during the second semester of the 1981 - 1982 school year. Those individuals enrolled in PE 100 - section 24, jogging and fitness, received one credit for participating in the study. The rest of the volunteers were women who answered flyers posted at strategic campus locations.

From an initial volunteer group of 63, the above group was selected based on their performance on a maximal graded exercise test of treadmill running and on their previous activity habits. Those who participated in a regular exercise program for at least 30 minutes, three days a week were rejected (ACSM, 1981). Those who obtained a maximal oxygen consumption value greater than $44.5 \text{ ml} \cdot \text{kg} \cdot \text{min}^{-1}$ were rejected. Individuals with a history of cardiorespiratory problems were also rejected from the study sample. An oral questionnaire prior to the exercise test was used to identify individuals with a history of cardiorespiratory problems (see Appendix A).

Out of the original 54 subjects selected for the study, nine were unable to complete participation. Four of 17 joggers dropped out. One failed to attend class, one strained her left ankle, one strained a muscle related to her hip, and one had abdominal problems for two weeks. Five of 18 controls refused to take their second exercise test. One sprained an ankle, one was involved in having a root canal done, one had an allergic reaction that put her in the hospital, one had back problems, and one refused to put herself through a maximal exercise test again. A total of 19 rebounders completed the study.

Initial Testing

All the maximal graded exercise tests were administered

in the Human Performance Laboratory at the University of Wisconsin - LaCrosse. All subjects were instructed over the phone to bring comfortable clothes to run in, to bring a pair of running shoes or tennis shoes, not to eat for at least one to one and one half hours prior to the test, and to come to the second floor of Mitchell Hall - Room 226.

When subjects arrived at the laboratory each was given an informed consent to read (see Appendix B). Before procedures began, each subject was asked to sign the consent and any questions about the testing or training were answered then. Each subject was weighed to the nearest 0.25 pound, without shoes. Electrodes were then placed on the subject's chest. Two electrodes were placed on the abdominal region and two directly below the clavicles on the mid - clavicular lines. The skin was abraded with alcohol swabs followed by rubbing with a kleenex. Alcohol was used once again, the skin was air dried, and the electrodes were applied. Limb leads I, II, and III were observed throughout the test.

The protocol used for the maximal treadmill run was the Modified Astrand Treadmill Protocol (Pollock, Wilmore, & Fox, 1978). The test began with a five minute warm - up. With this protocol, the speed was held constant between five and eight miles per hour. Most subjects were tested at six miles per hour, however, nine were tested at five point five miles per hour. The elevation was increased by two point five percent grade every two minutes following stage one.

Table 2 presents the protocol as used.

Table 2
Modified Astrand Treadmill Protocol

	Minutes	Speed	Grade
Warm - up	5	3.5 mph	2.5%
Stage I	3	6.0 mph	0.0%
Stage II	2	6.0 mph	2.5%
Stage III	2	6.0 mph	5.0%
Stage IV	2	6.0 mph	7.5%
Stage V	2	6.0 mph	10.0%
Stage VI	2	6.0 mph	12.5%

Pollpck et al. 1976, p. 40

The parameters measured during the test included maximal oxygen consumption, maximal heart rate, maximal ventilation, perceived exertion, respiratory exchange ratio, and time of the run. Heart rate measurements were obtained from a Viagraph electrocardiogram print out at the end of each stage and at maximum exertion. Rate was calculated by measuring the R to R interval for six seconds and multiplying by ten.

Maximal oxygen consumption and maximal ventilation were obtained via use of a Metabolic Measurement Cart (MMC) manufactured by Beckman Instruments. The cart contains an oxygen analyzer (OM - 11) and a carbon dioxide analyzer

(LB 2). The MMC was calibrated prior to each test with a gas sample containing a known amount of oxygen and carbon dioxide. The concentrations of each gas were determined previously by a medical technologist using the Scholander technique. Volume drift was checked prior to each test to within .05 of a liter. A drift between .05 and 99.95 (- .05) was considered acceptable.

Perceived exertion was determined using the Borg Scale (Borg, 1971). Table 3 shows a representation of the scale. The subject was asked to point to a number that best represented how they were feeling at the end of each stage of the protocol.

Table 3
Perceived Exertion 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	

Borg, G., 1971

Criteria for termination of the test included reaching

volitional exhaustion, achieving a respiratory exchange ratio (RER) of 1.0 or greater, or witnessing a decrease in or leveling off of VO_2 with an increase in workload (de Vries, 1980). When one or more of the above were attained the test was accepted.

A cool down period of not less than ten minutes followed. When heart rate reached 100 or below, the treadmill was stopped and the subject was unprepped. Each subject was instructed not to take an extremely hot or cold shower right after leaving the testing area.

Training Program

Joggers

The training program for the group of joggers began on March 23 and ended on May 6. During those seven weeks the subjects met for 45 minutes, four days a week. The sessions met Monday through Thursday and (consisted of a ten minute warm - up followed by 30 minutes of continuous walking and jogging. A five minute cool down ended each session. Subjects ran indoors or outdoors depending on the weather.) Jogging groups met at eight and ten AM and at six PM.

The subjects' work intensities were adjusted according to their heart rate responses. (Each subject was given a target heart rate at the start of the training sessions. Seventy - five percent of maximal heart rate obtained during the first treadmill test was used as target.) The heart

rates assigned ranged from 138 to 159. All subjects were instructed to take their pulses every ten minutes via the radial or carotid artery, and to increase or decrease their work - out intensity accordingly. Continuous movement as well as a gradual increase in intensity were emphasized during the seven weeks.

As time went by, subjects were able to increase the amount of time jogging and to minimize their walking periods. By the end of the seven weeks most joggers were able to jog continuously for 30 minutes. Four joggers still incorporated walking into their 30 minute work - out. Three of these joggers were plagued with injuries for one week and ran four extra days at the end of the study to make up the missed time.

Rebounders

The training program for the group of rebounders began March 23 and ended May 6. (During those seven weeks the subjects met for 45 minutes, four days a week.) The sessions met Monday through Thursday and (consisted of a ten minute warm - up followed by 30 minutes of continuous activity on a rebounder. A five minute cool down ended each session. Rebounders were instructed to bounce or jog in place and to incorporate arm movements into their routine. Subjects rebounded indoors or outdoors depending on the weather.) Rebounding groups met at seven AM, and at two, three, four, and five PM. Music was provided for the rebounders to jump to (see Appendix C). This

music helped to keep a fast tempo and assisted the subjects in maintaining their target heart rates. Boredom was kept at a minimum.

The subjects' work intensities were adjusted according to their heart rate responses. Each subject was given a target heart rate at the start of the training sessions. Seventy - five percent of maximal heart rate obtained during the first treadmill test was used as target. Heart rates assigned ranged from 126 to 162. All subjects were instructed to take their pulses every ten minutes via the radial or carotid artery and to increase or decrease their work - out intensity accordingly. Continuous movement as well as gradual increases in intensity were emphasized during the seven weeks.

Routines on the rebounders varied with the imaginations of the subjects. Some movements are illustrated in Appendix D. As time went by, the vigor of the routines increased as the subjects contended that they had to work harder to get their heart rates up to target.

Control Group Program

Control group subjects consisted of individuals from bowling and golf classes. Each subject was tested maximally via treadmill running in the same manner as the experimental groups. The control group was asked to refrain from any regular exercise activity for the period of seven weeks.

Final Testing

All experimental subjects were retested at the end of their training sessions. No more than three days passed between the end of training and the date of their final tests. The testing procedure was the same as during the initial test. Control subjects were tested seven weeks after their initial exercise test.

Statistical Analysis

Significance regarding any changes that occurred between and within groups during the seven weeks was determined by use of a 2 - way Mixed Design ANOVA with Repeated Measures. The level of confidence used to test the null hypothesis was .05. A Scheffé post hoc test was utilized to determine exactly which groups were significantly different when the Analysis of Variance yielded a significant F ratio. Parameters analyzed included relative and absolute $\dot{V}O_2$ max, maximal ventilation, perceived exertion, maximal heart rate, weight, time on the treadmill, and respiratory exchange ratio. An independent "t" test was used to determine the variability on the daily heart rate means of both groups.

CHAPTER IV
RESULTS AND DISCUSSION

Introduction

The following discussion deals with results obtained after statistical analysis was completed on the raw data collected from pre (T_1) and post (T_2) testing of all subjects. The statistical method used was a Mixed Design ANOVA with repeated measures. Significance for acceptance or rejection of the null hypothesis was based on the 0.05 level of confidence. A Scheffé post hoc test was calculated on those variables showing significance to determine exact areas of interaction. Daily heart rate averages were analyzed via an independent t - test.

This chapter has been divided into the following sections; subject characteristics, weight, training intensities, submaximal ratings of perceived exertion (SRPE), maximal ratings of perceived exertion (MRPE), treadmill run time (TRT), maximal heart rate (MHR), maximal ventilation ($\dot{V}E$ max), respiratory exchange ratio (RER), and $\dot{V}O_2$ max.

Subject Characteristics

The subjects for this study were 45 untrained female volunteers involved in basic physical education classes at the University of Wisconsin - LaCrosse, or who answered flyers

placed at strategic campus locations. The study was conducted during the second semester of the 1981 - 1982 school year. Table 4 details the subjects' physical characteristics.

Table 4
Means and Standard Deviations for Physical
Characteristics of Subjects

Variables	Joggers	Rebounders	Controls
Height (cm)	164.4 2.30	165.8 2.96	165.7 3.06
Weight (kg)	60.1 8.89	64.1 8.25	63.7 13.0
Age (yrs)	20.5 1.90	21.2 2.59	21.9 3.40

Body Weight

No significant changes ($p > .05$) were seen in body weight measurements from T_1 to T_2 (see Figure 1). Although, a 0.6% increase, a 1% decrease, and a 3% increase were seen in joggers, rebounders, and controls, respectively.

The measurement of body weight does not always reflect the results of exercise. The more accurate measurement of percent body fat is a better reflector of the changes in body composition seen as a result of exercise. A subject may not lose weight over a training period, yet may develop a greater percentage of lean body mass and decrease their

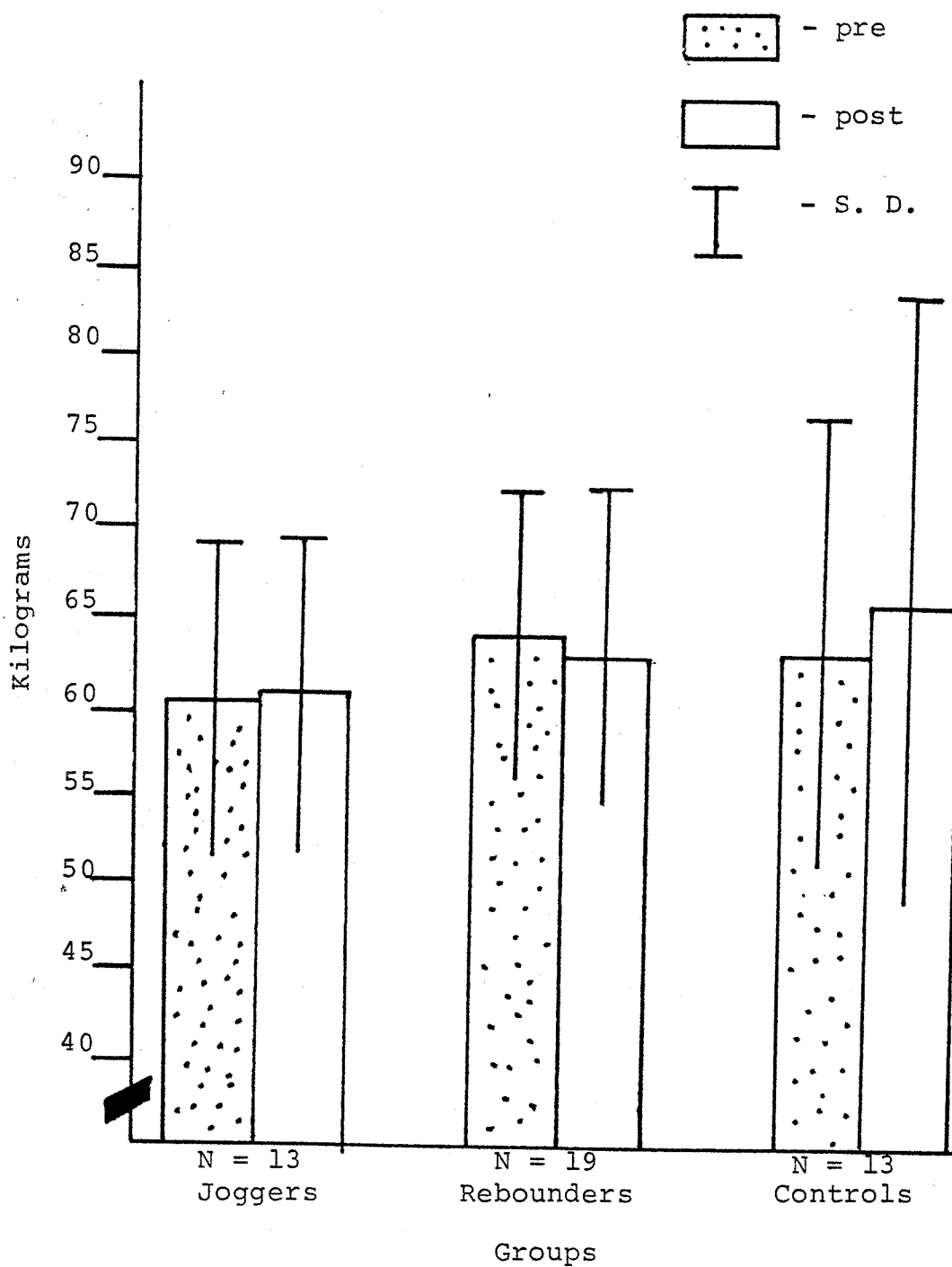


Figure 1. Pre - post training body weight measurements for joggers, rebounders, and controls.

percentage of body fat. Hence, a person may lose inches while remaining at the same weight.

Lean body mass has been shown to increase with training and to decrease with prolonged inactivity (Saltin et al., 1968). Gettman et al. (1976) found that their subjects increased body weight but decreased their percentage of body fat after 20 weeks of training. Wilmore et al. (1980) saw decreases in body fat percentage after 20 week training programs.

To determine lean body mass and percentage of body fat, either anthropometric measurements using skinfold calipers or hydrostatic weighing are needed. These measurements were not obtained during this investigation. Informally, four subjects in the rebounding group reported losing inches around their hips and waist over the seven week training program.

Training Intensities

Intensity of training for the experimental subjects of this investigation was regulated by heart rate response. Each subject was assigned a target heart rate based on 75% of maximal heart rate achieved on their treadmill runs. In actuality, average daily heart rates for the joggers ranged from 141 to 172 beats per minute with a mean intensity of 82% of maximum. The rebounders average daily heart rates ranged from 130 to 165 beats per minute with a mean intensity

of 78% of maximum.

Average daily heart rates of the two experimental groups were compared using an independent t - test. No significant difference ($p > .05$) was found between the groups. The critical value of t was -1.667 with 30 degrees of freedom. The test value of t was $.258$.

The joggers had no problem reaching their target heart rates. Likewise, the rebounders achieved their target heart rates throughout the study. Katch and Villanacci (1981) reported an average heart rate of 115.8 beats per minute in their subjects who were limited to 54 to 68 steps per minute on the rebounder. It is possible that the decrease in percent body fat and increase in $\dot{V}O_2$ max reported by White (1980) but disputed by Katch and Villanacci (1981) was due to a higher exercise intensity achieved by White's subjects, who may not have been limited to simple jogging in place. The rebounders in the present investigation were given no limits other than having to continue rebounding movements for 30 minutes each session. They voiced feelings of having to work harder to achieve the same heart rates by the end of the training program.

Submaximal Ratings of Perceived Exertion (SRPE)

A significant decrease ($p < .01$) was seen in SRPE in the jogging group from T_1 to T_2 (see Figure 2). Their subjective ratings of how they felt ten minutes into the treadmill test significantly decreased from 15.2 to 13.6. The rebounders

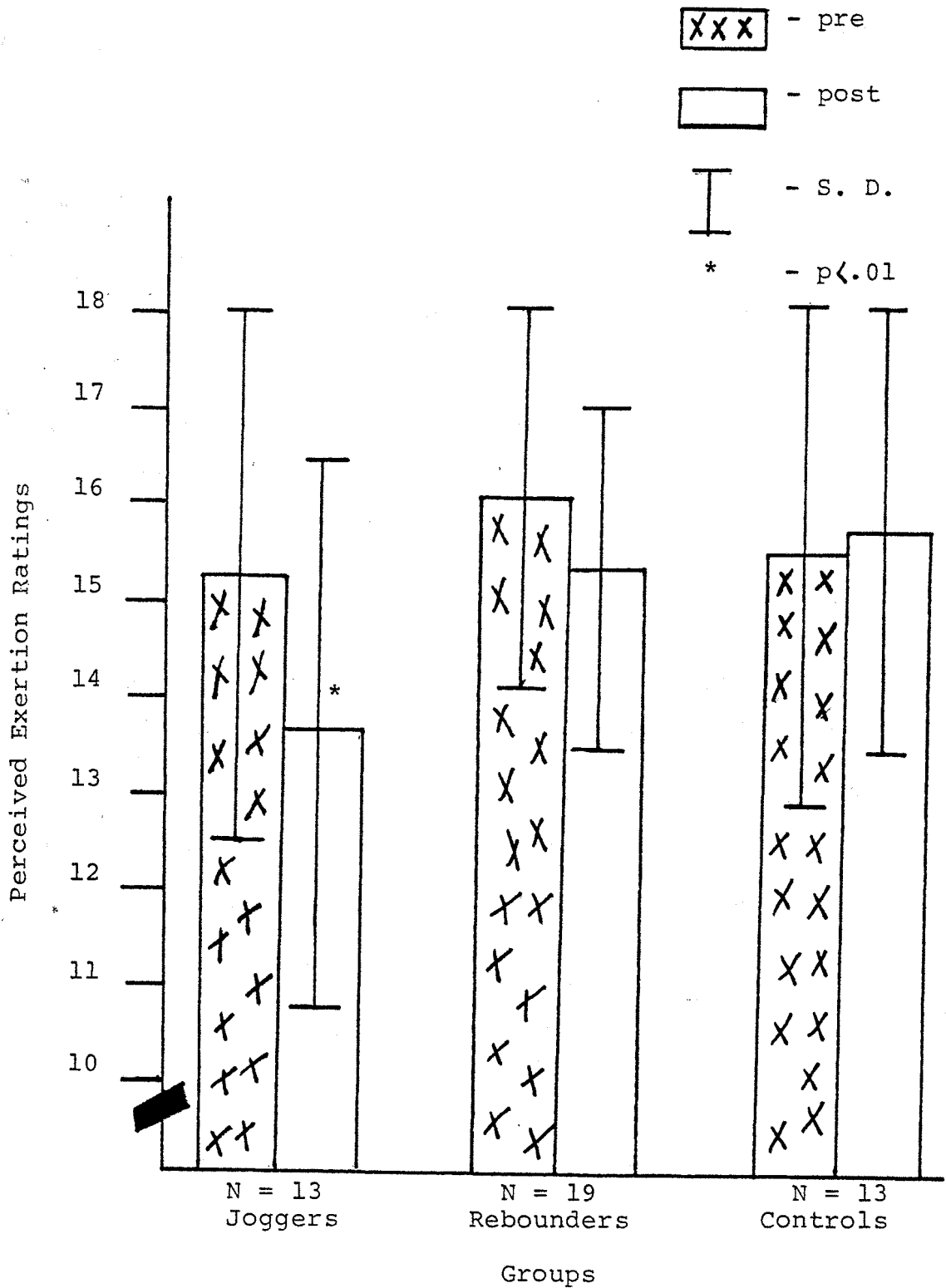


Figure 2. Pre - post training SRPE values for joggers, rebounders, and controls.

and controls did not reflect a similar change. There was a significant difference ($p < .01$) between the T_2 values of joggers and rebounders and joggers and controls. This reflects less subjective feelings of fatigue within the joggers during submaximal exercise at T_2 .

A possible explanation could relate to specificity of training. The joggers may have felt more comfortable jogging because they trained doing exactly that for seven weeks. The rebounders and controls were expected to refrain from jogging during those seven weeks and may have felt fatigued earlier on the treadmill.

Maximal Ratings of Perceived Exertion (MRPE)

No significant changes ($p > .05$) were observed in MRPE from T_1 to T_2 for all groups (see Figure 3). All maximal ratings averaged to 19. This would seem to indicate that maximal testing was achieved. This was expected if all the subjects were at their true physiological maximum and the work they were doing was anaerobic.

Treadmill Run Time (TRT)

Nonsignificant increases ($p > .05$) were seen in TRT from T_1 to T_2 in all three groups. Joggers, rebounders and controls increased 37, 24, and 16 seconds, respectively, from pre to post training.

The TRT value for all three groups combined was

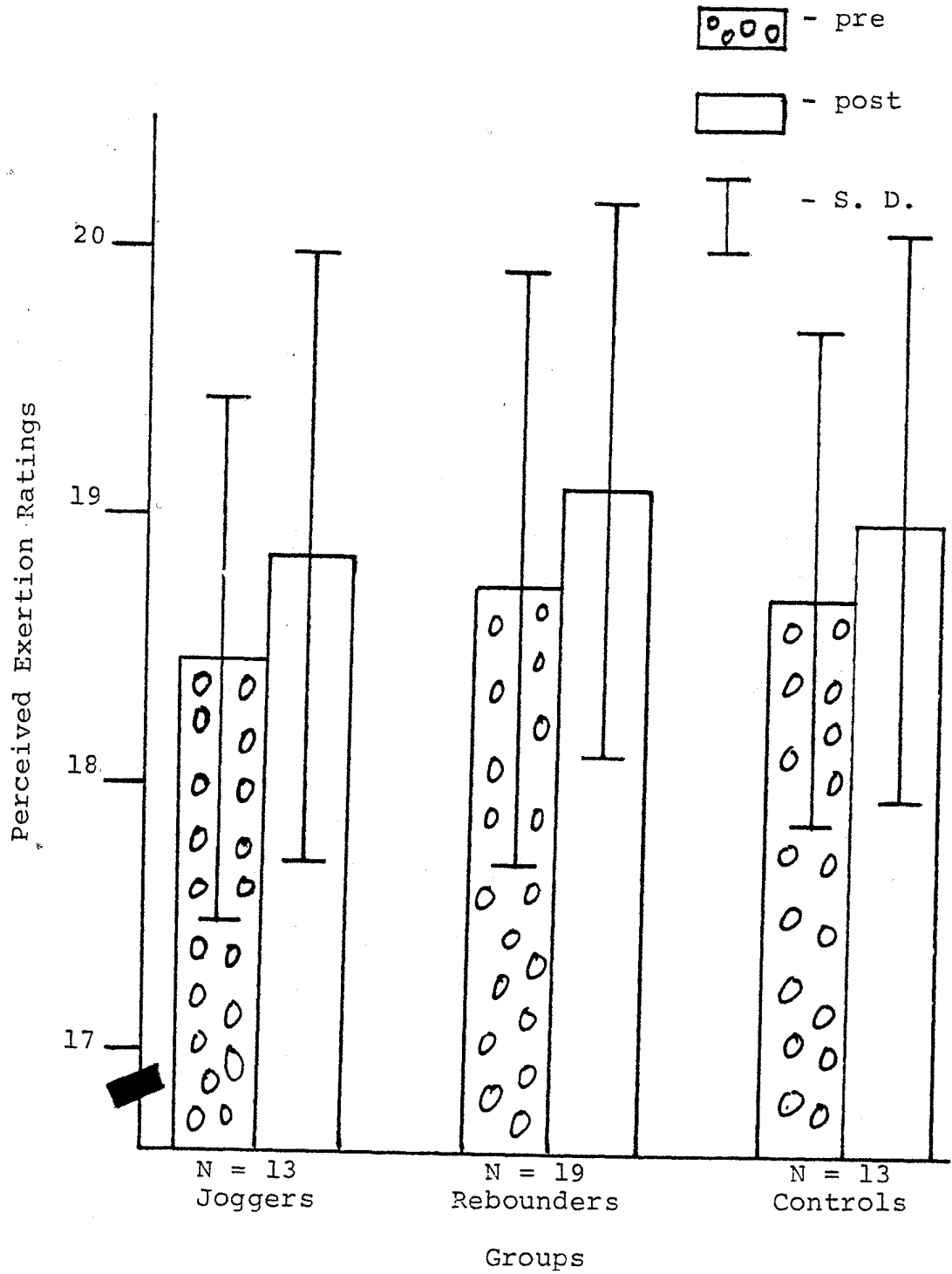


Figure 3. Pre - post training MRPE values for joggers, rebounders, and controls.

significantly higher ($p < .01$) for T_2 than for T_1 . An average increase of 25 seconds was seen from T_1 to T_2 . Again, this could reflect changes in motivation and familiarization with testing equipment. This could also represent an improvement in performance.

Maximal Heart Rate

There was a significant increase ($p < .01$) in maximal heart rate values from T_1 to T_2 in both experimental groups (see Figure 4). A 5% increase of ten beats per minute was seen in the jogging group. The rebounders increased 3% or eight beats per minute. The controls showed no change.

Many studies have shown the opposite of these results. Researchers have seen slight decreases or no change in maximal heart rates after training (Karvonen, 1957; Ekblom et al., 1968).

Ekblom et al. (1968) showed no change in heart rate at maximum with an increase in cardiac output. It is generally accepted that stroke volume improves with training, causing the increase in cardiac output as heart rate remains the same or even decreases slightly.

Astrand and Rodahl (1977) stated that during maximal exercise the heart rate is "remarkably similar under various conditions" (p. 189).

The unusual results obtained from this study could reflect a previously mentioned limitation. The pre training exercise test was done without subjects being introduced

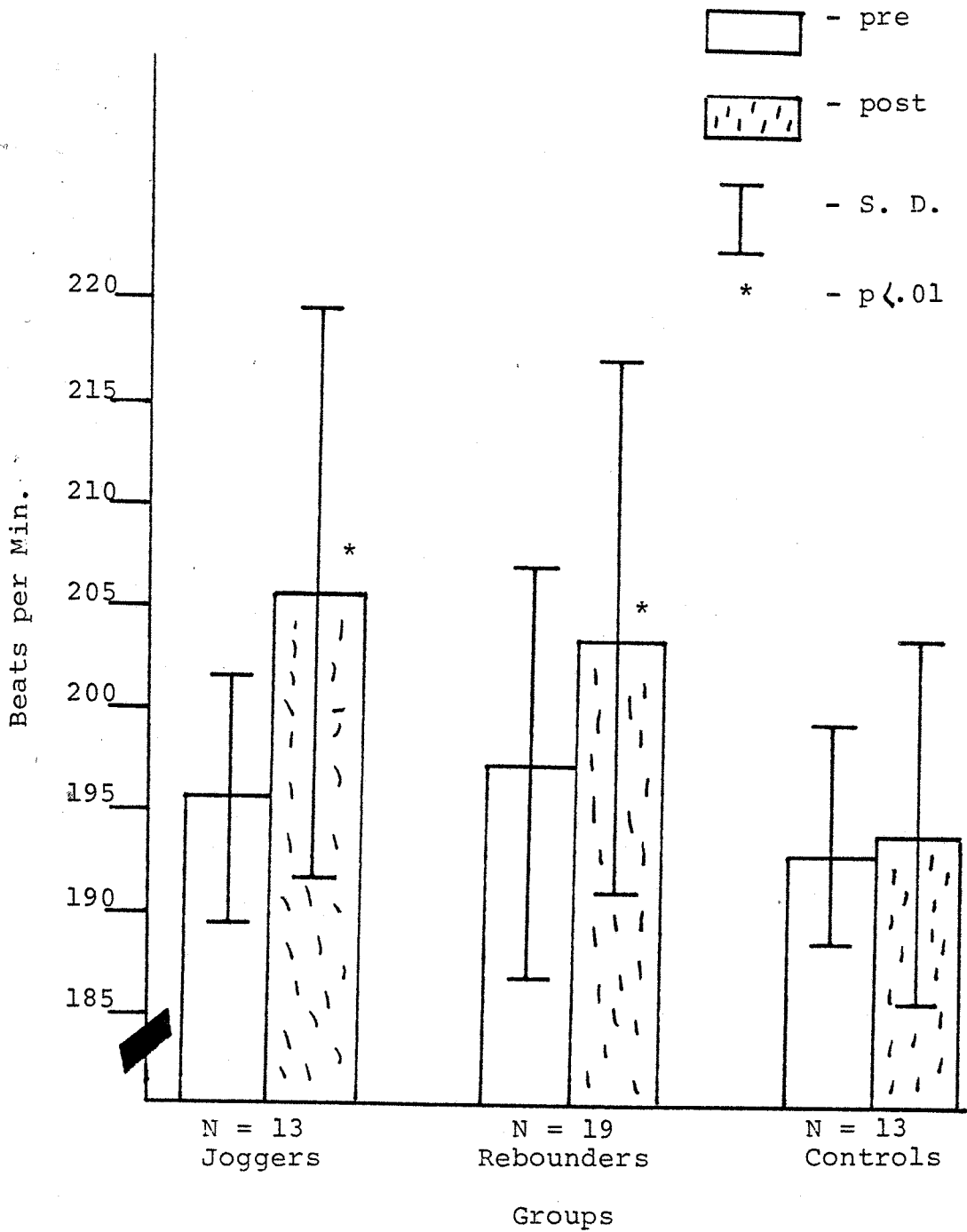


Figure 4. Pre - post training maximal heart rate values for joggers, rebounders, and controls.

to the treadmill and bulky headgear. Their pre training treadmill run may have been subjectively cut short reflecting heart rate values below maximum. Another factor involved could have been motivation. The second test held a stronger impetus for the experimental subjects. They had a stake in the results of the second test. Ten percent of their grade in the class was based on improvement. Also, most wanted to see an improvement after training for seven weeks. One other factor that may have played a role in the higher post training heart rate values was heat. The pre test was done during the winter when humidity and temperature was low. Post tests were done in May when the humidity was higher and the temperatures were also higher. However, high temperatures have been shown to effect submaximal heart rates more than maximal heart rates (Astrand & Rodahl, 1977).

Maximal Ventilation

Nonsignificant increases ($p > .05$) were seen in maximal pulmonary ventilation in both experimental groups from T_1 to T_2 as a result of training (see Figure 5). There were significant differences ($p < .01$) seen between the T_1 values for controls and the T_1 values for joggers and rebounders. This could be attributed to the heavier weight recorded for the controls. This, along with a taller body frame has a definite effect on lung capacity (Astrand & Rodahl, 1977). One very large lady was part of the control group for this study, and may have skewed the control values.

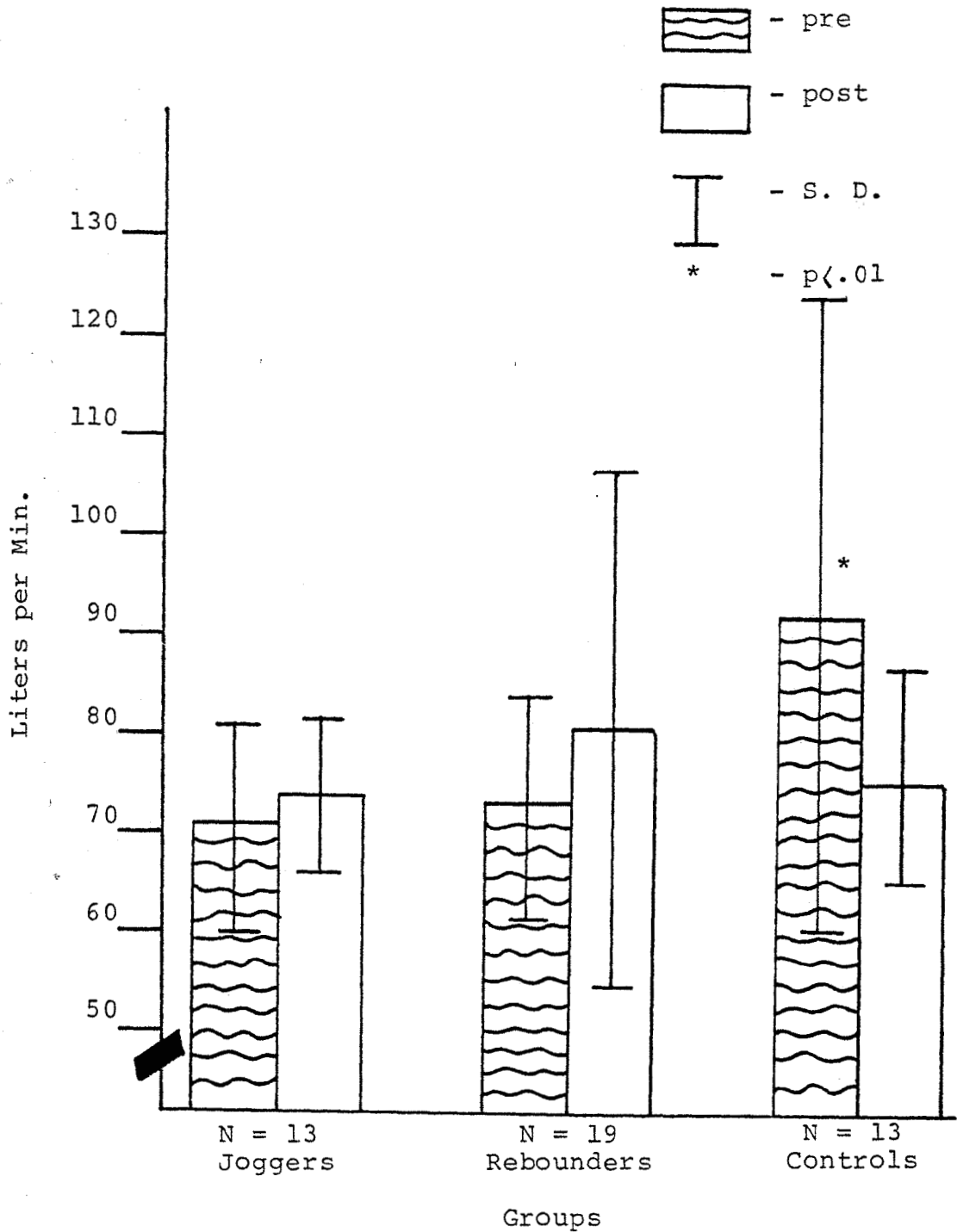


Figure 5. Pre - post training $\dot{V}E$ max values for joggers, rebounders, and controls.

Other studies report significant increases in $\dot{V}E_{max}$ as a result of training (Wilmore et al., 1980; Kilbom, 1971; Wilmore et al., 1970). Astrand and Rodahl (1977) stated that ventilation and $\dot{V}O_2$ are positively correlated. Ventilation increases as O_2 uptake increases. As oxygen is consumed, more carbon dioxide and lactic acid are produced. Ventilation must increase to dispose of these by-products (Astrand & Rodahl, 1977).

Respiratory Exchange Ratio

No significant changes ($p > .05$) were seen in RER values from T_1 to T_2 (see Figure 6). Values for RER were greater than 1.00 for all groups before and after training. This was an indication that all the subjects reached the point of producing a greater volume of carbon dioxide than the volume of oxygen they were utilizing during their maximal exercise tests. This would also seem to indicate that maximal tests were achieved.

Maximal Oxygen Consumption

No significant changes ($p > .05$) were found in either relative or absolute measurements of $\dot{V}O_2_{max}$ from T_1 to T_2 for both experimental groups (see Figures 7 & 8).

The joggers reflected an absolute 3% increase of $0.1 \text{ L}\cdot\text{min}^{-1}$ and a relative 4% increase of $1.46 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ pre to post training. Similarly, the rebounders demonstrated a 3%

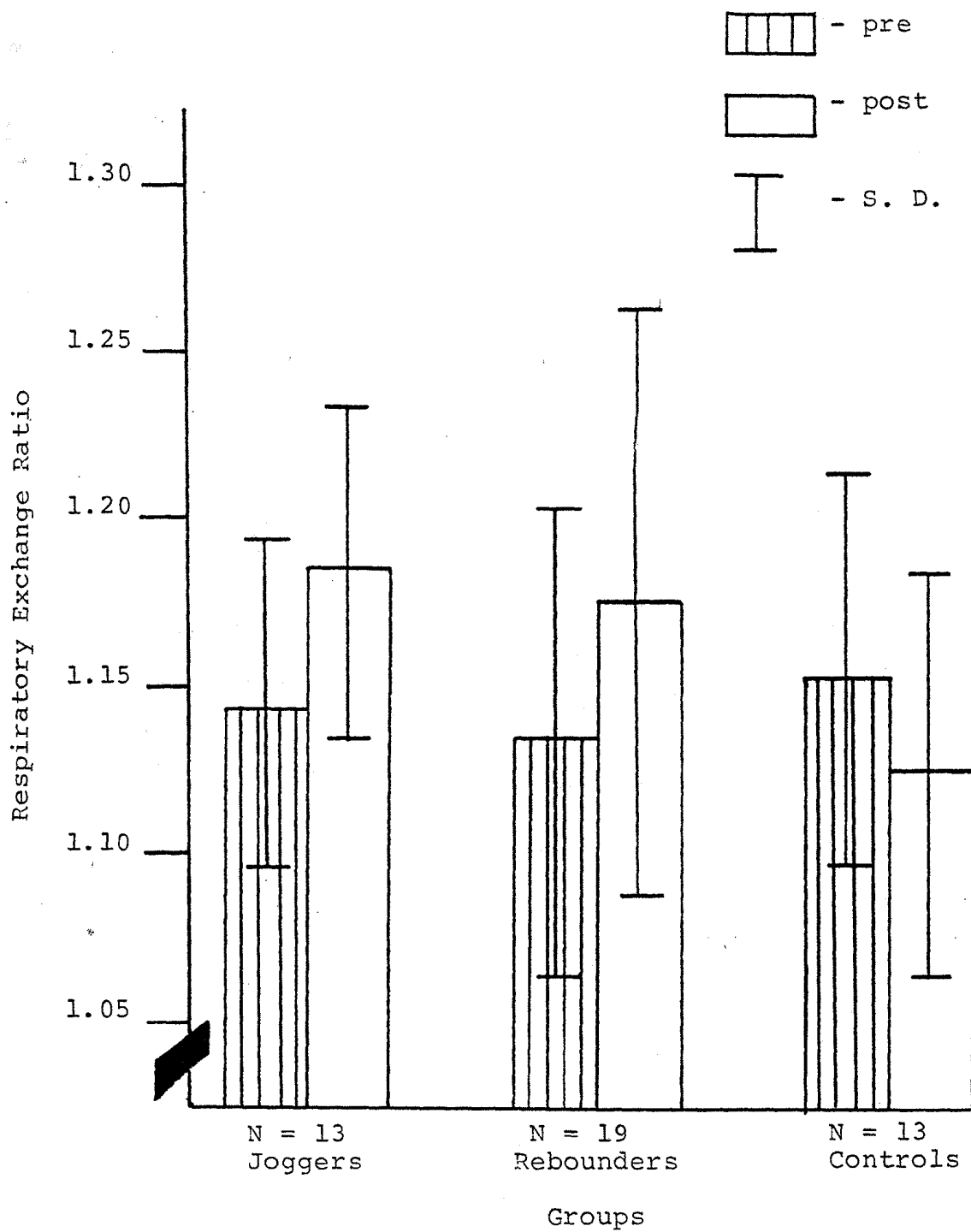


Figure 6. Pre - post training RER values for joggers, rebounders, and controls.

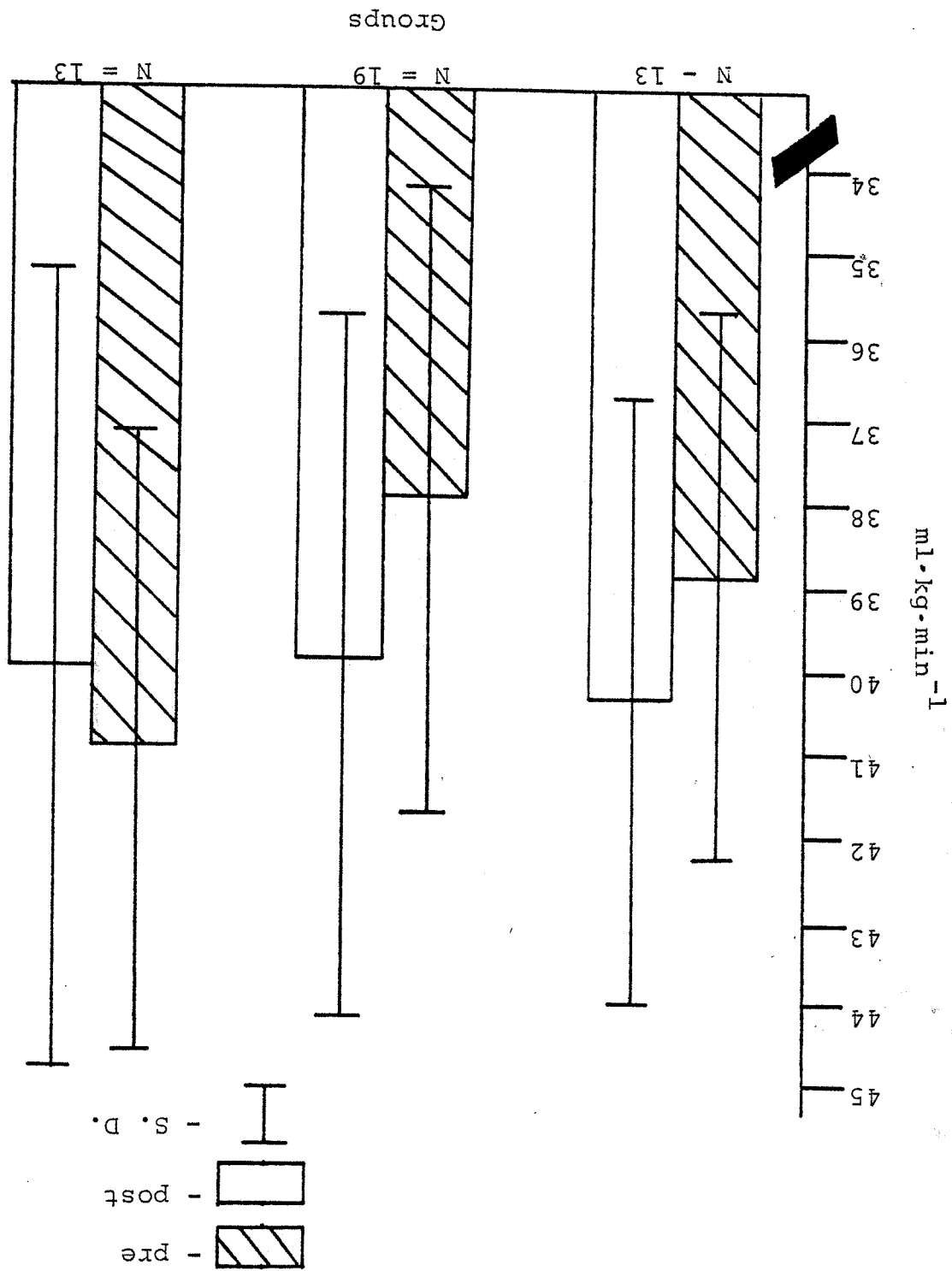


Figure 7. Pre - post training VO_2 max values (ml·kg·min⁻¹) for joggers, re-borders, and controls.

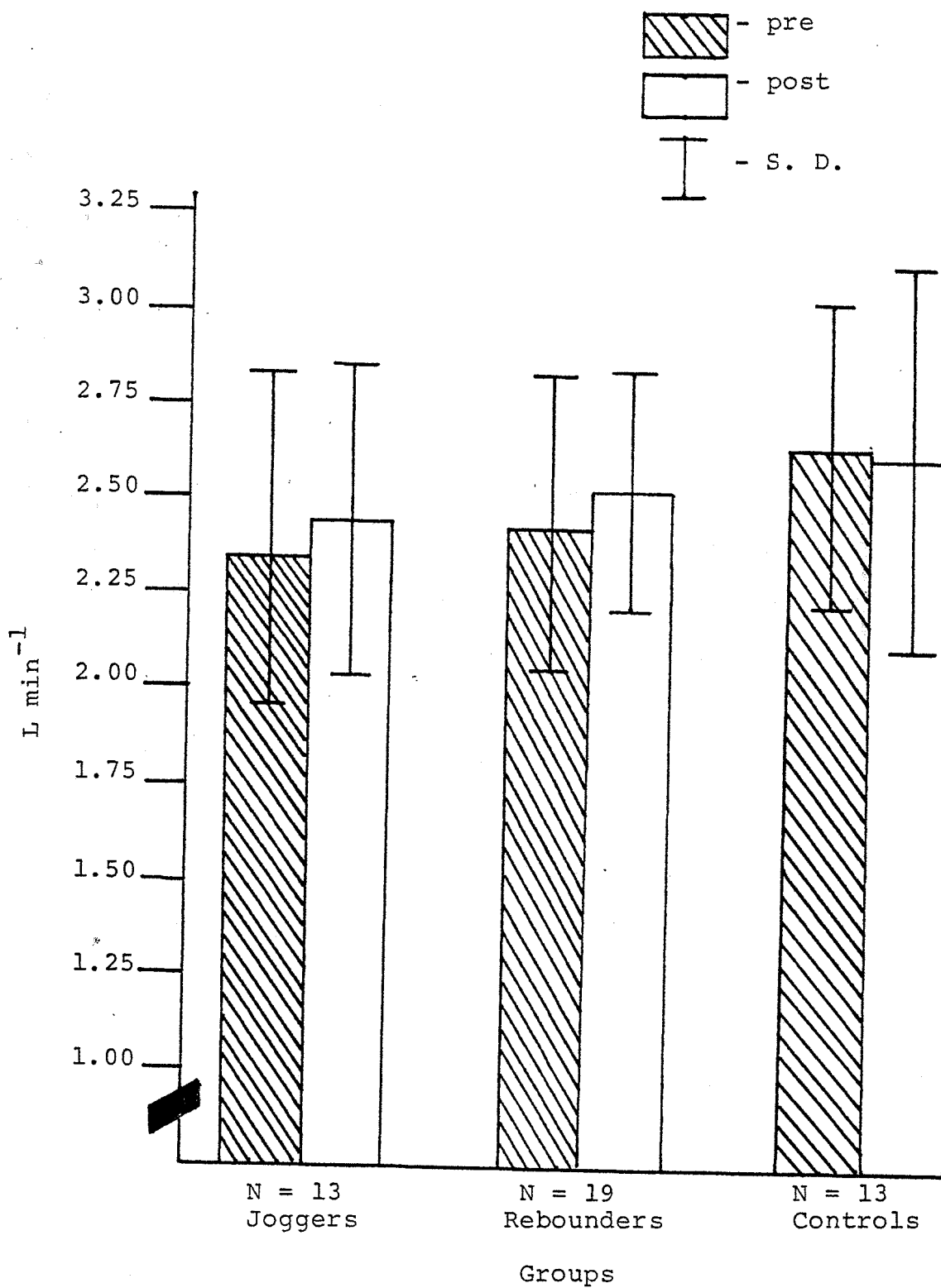


Figure 8. Pre - post training $\dot{V}O_2$ max values ($L \cdot min^{-1}$) for joggers, rebounders, and controls.

increase of $0.08 \text{ L}\cdot\text{min}^{-1}$ and a 5% increase of $1.91 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$. The controls showed no change and a 2% decrease, respectively.

The mean pre test $\dot{V}O_2$ max values of $38.85 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$, $37.91 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$, and $40.82 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ for joggers, rebounders, and controls, respectively, are slightly higher than those generally reported in the literature for untrained college aged women. Edwards (1974) reported average $\dot{V}O_2$ max values of $27.26 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ and $26.18 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ pre training. Cunningham and Hill (1975) averaged $28 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ when measuring sedentary college women. In contrast, Eisenman and Golding (1975), Stewart et al. (1977), and Kearney et al. (1976) reported average $\dot{V}O_2$ max values ranging from $35.7 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ to $38.36 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ in untrained females of college age.

In the present study, eight volunteers had initial $\dot{V}O_2$ max values greater than $43 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$. Four of these subjects were in the control group, two were in the jogging group, and two were in the rebounding group. These subjects, according to Astrand and Rodahl (1977), would be classified as trained. The two rebounders reflected initial values of $44.54 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ and $43.2 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$. The two joggers were similar with values of $44.54 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ and $43.17 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$.

The $\dot{V}O_2$ max values for the joggers ranged from $32.67 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ to $44.54 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$. Range for the rebounders was $28.07 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ to $44.54 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$. These ranges

demonstrate the large variability found between the subjects. The present emphasis on a fit body and the importance of activity to health and well being have pushed the population into physical exercise. The amount of people involved seems exaggerated among college students. It was difficult to find a homogenously untrained, low fitness level group of college women at the University of Wisconsin - LaCrosse, a strong fitness minded campus, to volunteer for this study.

Most investigators have reported improvements in $\dot{V}O_2$ max values after training (Wilmore et al., 1970; Pollock et al., 1977; Kearney et al., 1976; Edwards, 1974; Eisenman & Golding, 1975; Cunningham & Hill, 1975). The studies ranged from four weeks to 20 weeks in length. Other studies have shown relationships between improvement in $\dot{V}O_2$ max and intensity of exercise, level of initial fitness, and length of training program.

Looking at the study by Edwards (1974), the improvement seen in $\dot{V}O_2$ max was over a four week period. Also observed was the low initial fitness of her subjects which was reflected in $\dot{V}O_2$ max values of 27.26 and 26.18 ml·kg·min⁻¹.

Eisenman and Golding (1975) trained their group for 14 weeks with positive results. Their initial fitness levels were also higher at 38.1 and 39.0 ml·kg·min⁻¹.

Sharkey and Holleman (1967) trained for only six weeks and saw positive improvement in the high intensity (180 beats per minute) group only. Those training at 120 and 150

beats per minute showed no significant increases in $\dot{V}O_2$ max.

Daniels et al. (1978) saw improvement in the $\dot{V}O_2$ max of untrained subjects after four weeks of training. After four weeks no further improvement was seen. Their trained subjects saw no improvement in $\dot{V}O_2$ max after four or eight weeks. However, both trained and untrained groups improved their running performance.

Wilmore et al. (1980) trained subjects for 20 weeks and saw a definite improvement, as did Pollock et al. (1977).

Rosentswieg and Burrhus (1975) saw no increase in $\dot{V}O_2$ max after four weeks of training at 160 beats per minute. Their study involved college aged women.

From the investigations mentioned above, the importance of finding the most optimal combination of intensity, frequency, duration, and length of training program can be appreciated. Lack of length must be compensated for by increasing intensity, duration, or frequency. Lower intensity exercises must be done for a longer period of time. Exercises done only once or twice a week must have higher intensities than those done four or five times a week. The intensity for the present investigation was well within the effective range as was duration and frequency. However, the length of the training program was only seven weeks. Most studies that showed improvement in $\dot{V}O_2$ max lasted nine to 14 weeks. Those of shorter length showing significant improvement involved higher intensities or lower initial

fitness levels.

Other factors that could have influenced the nonsignificant increase in $\dot{V}O_2$ max in both joggers and rebounders were illness, injuries, and absence. Two joggers nursed ankle injuries through the last week of training causing their training sessions to be cut to 20 minutes. Two joggers as well as two rebounders developed respiratory tract infections and exercised an extra week to make up the days they missed. Average number of absences were five days and three days for joggers and rebounders, respectively. Rebounders were required to make up their absences on Friday of each week and joggers were required to jog one day over the weekend to make up their missed sessions.

As stated earlier, the increase in max HR may have been related to lack of a true maximal effort by the subjects on the first treadmill test. If this were the case then the $\dot{V}O_2$ max values should also have increased significantly on the final tests. For some reason, this was not the case.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

This study was designed to compare responses of subjects participating in a rebounding and a jogging program with special attention paid to improvement in cardiovascular status. The subjects consisted of 45 college women, ages 19 to 32, all of whom were untrained. The subjects were divided into 13 joggers, 19 rebounders, and 13 controls. None of the women were involved in regular exercise programs at the start of the study.

Each subject was tested via a pre and post training Modified Astrand Maximal Treadmill run. The women were then trained for seven weeks at a frequency of four days per week and a duration of 30 minutes per session. A training heart rate was assigned to each, based on 75% of their maximal heart rate obtained during the treadmill runs. Each subject recorded a ten second heart rate at ten minute intervals during the training sessions. In actually, the joggers and rebounders trained at 82% and 78%, respectively, during the seven weeks. The training periods were preceeded by a ten minute warm - up and followed by a five minute cool down. Parameters measured before and after training included body weight, $\dot{V}O_2$ max, maximal heart rate, $\dot{V}E$ max, RER, SRPE,

MRPE, and TRT.

Statistical differences between the training programs were determined by use of a Mixed Analysis of Variance with Repeated Measures. A Scheffé post hoc test was utilized to establish the areas of significance. The 0.05 level of confidence was used to determine significance.

No significant differences ($p > .05$) were seen in relative or absolute $\dot{V}O_2$ max values, in body weight measurements, in maximal perceived exertion ratings, or in RER values from T_1 to T_2 . No significant changes ($p > .05$) were seen in the experimental subjects from T_1 to T_2 regarding $\dot{V}E$ max. A significant decrease ($p < .01$) was observed for $\dot{V}E$ max values from T_1 to T_2 in control subjects. Maximal heart rate values increased significantly ($p < .01$) for both experimental groups from T_1 to T_2 . Control values for maximal heart rate remained the same from pre to post test. Significant decreases ($p < .01$) were found for perceived exertion values in the tenth minute of the treadmill run from T_1 to T_2 for the joggers only. The joggers had a significantly lower ($p < .01$) SRPE value than either the rebounders or the controls at T_2 . The TRT for all groups combined was significantly lower ($p < .01$) at T_1 than at T_2 .

Conclusions

Based on the statistical interpretation detailed in the preceding chapter and the limitations and delimitations

of this study, the following conclusions were offered.

There were no significant increases ($p > .05$) seen in $\dot{V}O_2$ max values after seven weeks of rebounding or jogging. Therefore, no significant cardiovascular improvements were seen as a result of seven weeks of training through jogging or rebounding in these subjects.

There were no significant ($p > .05$) changes in $\dot{V}E$ max in experimental subjects as a result of seven weeks of rebounding or jogging.

There were no significant changes ($p > .05$) observed for body weight measurements or for MRPE values in both experimental groups as a result of seven weeks of training.

There was a significant decrease ($p < .01$) in perceived exertion values at the tenth minute of the treadmill run as a result of seven weeks of training via jogging.

There was a significant increase in TRT ($p < .01$) for all groups combined as a result of seven weeks of training.

There was a significant increase ($p < .01$) in maximal heart rate values for both experimental groups after seven weeks of jogging and rebounding.

Rebounding and jogging are exercise modalities capable of providing a means to obtain exercise heart rates of 75% of maximum or greater in untrained college women.

The results of this investigation inferred that training on a rebounder or through jogging for seven weeks, four days a week, for 30 minutes each session at training heart rates

of 75% of maximum does not induce a training effect that would have been reflected by an increased oxygen consumption, an increased $\dot{V}E$ max, and a lowered or stabilized maximal heart rate. The results did verify that rebounding can be vigorous enough to ellicit a heart rate of adequate intensity for training to occur if done long enough and often enough. The results of this investigation also demonstrated that seven weeks of training resulted in a higher endurance level reflected in the ability of the subjects to run longer exercise tests after the program of exercise. In the case of the joggers, the longer tests were accompanied by a lower subjective rating of physical fatigue.

Within the confines of this study, a training effect or an increase in physical fitness was not seen after exercising through jogging or through rebounding. This is not to say that rebounding and jogging are exercises that do not promote fitness. The women involved in this study had higher initial levels of fitness than the average person just beginning a fitness program. They may have needed more time, more frequent exercise sessions, or higher working goals to achieve an improvement in fitness over the seven weeks. Heart rates were high enough and this indicates that if done long enough, both exercises could help develop a more fit body. In conclusion, the topic needs further investigation and the exercise modality of rebounding should not be considered inadequate until more studies are done.

Recommendations

As a result of the conclusions presented and based on many of the statements published about rebounding and many of the research studies done on jogging, the following recommendations were offered.

A repeat study of similar design with the exception of implementing an introductory visit to the laboratory is suggested. Familiarization of subjects to the laboratory measuring devices may yield a more accurate initial treadmill test.

A longer study lasting 10 to 20 weeks, investigating the cardiovascular benefits of rebounding should be done.

A study measuring percent body fat should be done to assess the actual loss of body fat that can not be represented by body weight measurements.

A study involving measurement of impact force and stress to the joints should be designed to prove or disprove statements claiming reboundings superiority over jogging in this respect.

A study involving cardiac patients should be designed to assess rebounding's role in cardiac rehabilitation.

A study comparing rebounding to other popular exercise modalities such as swimming, bicycling, or jump roping should be designed and implemented.

A study involving older subjects should be completed to

determine the feasibility of rebounding as an exercise for middle aged and elderly populations.

A study involving athletes or highly trained individuals should be designed to determine if high intensity exercise can be sustained on a rebounding device.

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APPENDIX A

ORAL MEDICAL QUESTIONNAIRE

Oral Health Questionnaire

- 1) Have you ever had trouble with your heart before?
- 2) Are you taking any drugs for your heart?
- 3) Have you ever been told your blood pressure was high?
- 4) Are you taking any drugs for high blood pressure?
- 5) Have you ever had trouble with your lungs or with breathing?
- 6) Are you taking any drugs for your breathing?
- 7) Have you ever fainted?
- 8) Is there a history of heart disease, respiratory disease, or hypertension in your family?

APPENDIX B

CONSENT FORM

INFORMED CONSENT

Rebounding versus jogging in college females

I, _____ hereby agree to participate in the study conducted by M. J. Forrest and her assistants. I understand that the procedures involved in this study have been approved by Wayne Kaufman, Richard Fletcher, and Nancy Butts, her supervising thesis committee.

I agree to take part in a maximal graded exercise test on this date and approximately seven weeks from now. As explained to me, I will be walking and running on a motor driven treadmill while my electrocardiogram is monitored. I will be wearing a mouthpiece attached to a hose. The hose will be connected to a computer used to measure oxygen levels during the test. The difficulty of the test will gradually increase by increasing the speed and height of the treadmill, until my maximal effort is attained. I understand the potential risks associated with exercise tests. These include lightheadedness, leg and chest discomfort, fainting, muscle cramping, and rarely heart attack or sudden death. I also understand that the laboratory is equipped for such emergencies and that the testing personnel are trained for such emergencies. I accept the risks involved.

If I am in the rebounding or jogging group I also agree to take part in a seven week training program. I understand the training will be by one of two methods; jogging or rebounding. I agree to do the type of exercise that is selected for me. I am willing to exercise four days a week for thirty minutes each day. I understand the risks involved. These include muscular fatigue, joint fatigue or injury. I also understand the possible benefits I may obtain such as increased cardiovascular fitness, increased stamina, and a feeling of well being.

To my knowledge I am not affected with any disease or have any limiting physical conditions or disabilities, especially with respect to my heart, that would preclude such a strenuous exercise.

I understand that any information obtained about me in connection with this study will remain confidential. Any data published will be done so anonymously.

I am aware that I may discontinue my participation in this study at any time without penalty or threat.

Any questions I have may be directed to M. J. Forrest.

INFORMED CONSENT con't:

Signature _____

Date _____

Witness _____

Date _____

APPENDIX C

MUSIC FOR REBOUNding SESSIONS

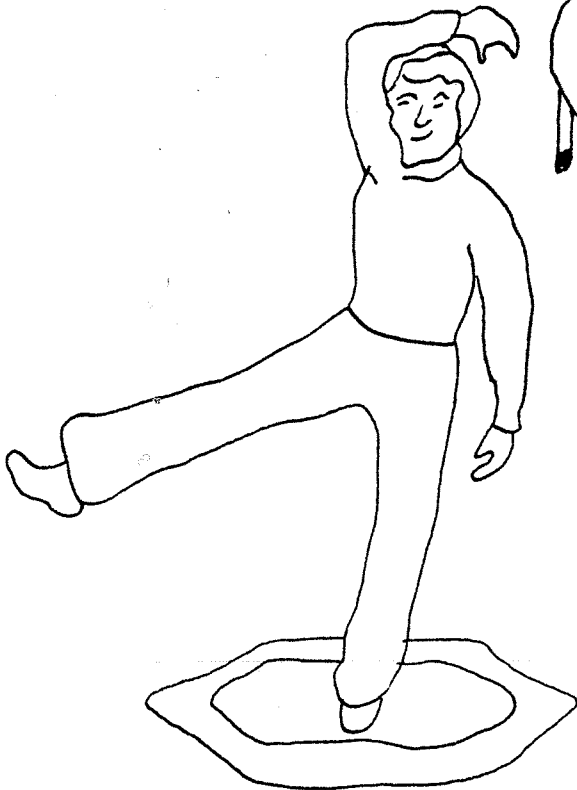
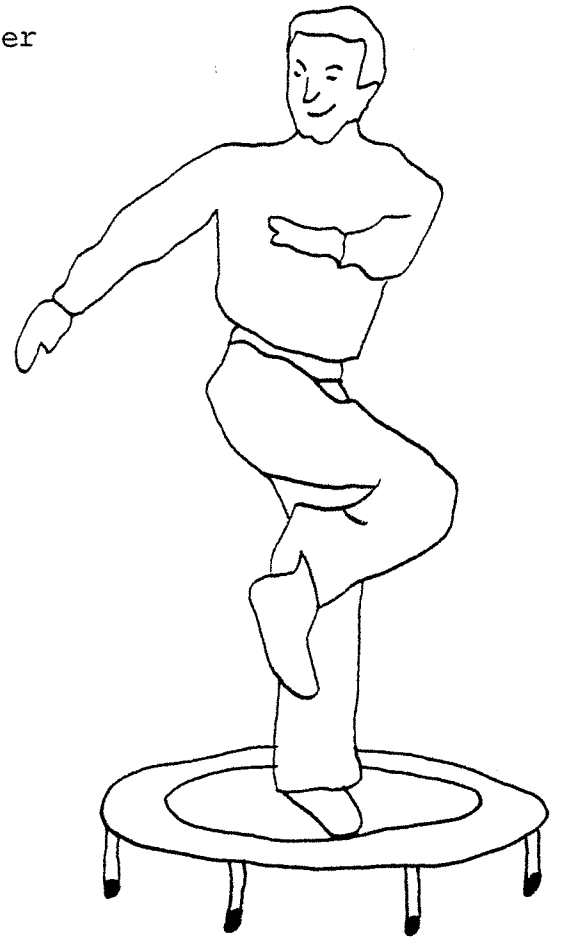
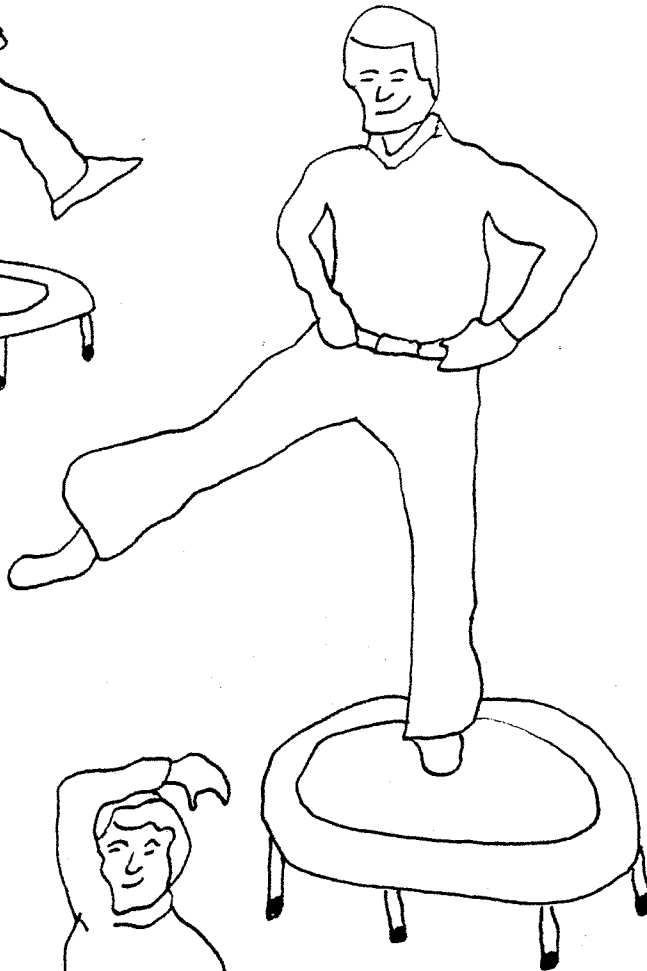
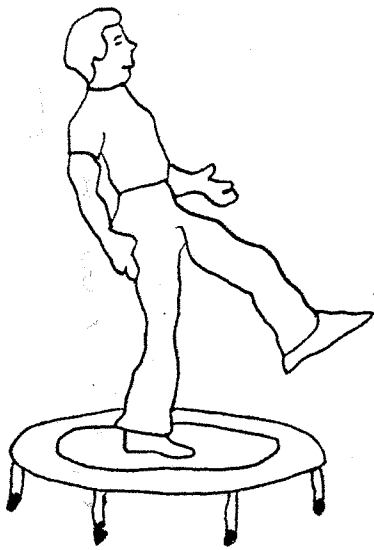
Examples of Music Used for Rebounding Sessions

- 1) The Horizontal Bop by Bob Segar - Capitol Records.
- 2) On Broadway by George Benson - from the original motion picture soundtrack of All That Jazz - Casablanca Record and Filmworks.
- 3) Betty Lou's Gettin' Out Tonight by Bob Segar - Capitol Records.
- 4) Jump Shout Boogie by Barry Manilow - Arista Records.
- 5) Bandstand Boogie by Barry Manilow - Arista Records.
- 6) American Pie by Don McClean - Liberty Records.
- 7) Me and Julio Down By The Schoolyard by Simon and Garfunkel - Warner Bros. Records Inc.
- 8) Mrs. Robinson by Simon and Garfunkel - Warner Bros. Records Inc.
- 9) Crunchy Granola by Neil Diamond - MCA Records.
- 10) Cherry Cherry by Neil Diamond - MCA Records.
- 11) Night Thunder by Bill Murphy - Epic Records.
- 12) The Ballad of John and Yoko by John Lennon and Paul McCartney - Maclen Music, Inc.
- 13) Easy Driver by Kenny Loggins - Columbia Records.
- 14) Hot Patootie - Bless My Soul from the soundtrack of The Rocky Horror Picture Show - Ode Sounds and Visuals.

APPENDIX D

MOVEMENTS ON THE REBOUNDER

Movements on the Rebounder



APPENDIX E

PRE / POST MEANS AND
STANDARD DEVIATIONS
OF ALL VARIABLES ANALYZED

Pre / Post Means and S. D. of all Variables

	Joggers	Rebounders	Controls
$\dot{V}O_2$ max (L·min ⁻¹)	2.34 ^a	2.43	2.62
	.42	.39	.40
	2.43 ^b	2.51	2.61
	.40	.32	.50
$\dot{V}O_2$ max (ml·kg·min ⁻¹)	38.9	37.9	40.8
	3.3	3.8	3.8
	40.3	39.8	40.0
	3.6	4.2	4.8
Max HR	195.4	197.0	193.7
	6.5	10.4	5.7
	205.5	203.8	194.1
	13.9	13.5	8.9
$\dot{V}E$ max	70.2	72.4	91.4
	10.4	11.2	31.8
	73.0	80.4	75.1
	7.7	26.3	10.8
RER	1.14	1.13	1.15
	.05	.07	.06
	1.18	1.17	1.12
	.05	.09	.06
TRT	815	799	775
	107	105	80
	852	823	791
	94	113	99
MRPE	18.5	18.8	18.8
	.97	1.13	.93
	18.9	19.2	19.0
	1.14	1.02	1.08

	Joggers	Rebounders	Controls
SRPE	15.2	16.1	15.5
	2.74	1.96	2.61
	13.6	15.3	15.8
	2.84	1.79	2.24
Weight	60.1	64.1	63.7
	8.9	8.3	13.0
	60.4	63.4	66.1
	8.7	9.1	17.7

a = pre
b = post