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THE EFFECTS OF A SEVEN WEEK SLIDEBOARD TRAINING PROGRAM

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

in

Exercise Physiology

Department of Kinesiology
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The Thesis of Douglas B. Smith for the degree of Master of Science in Exercise Physiology is approved.

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ABSTRACT

The slideboard is a new exercise device that may provide a form of aerobic exericse. The cardiorespiratory and muscular strength and endurance benefits have not been established. Therefore, the purpose of this study was to determine the changes in leg strength and endurance, aerobic capacity, and body composition, during seven weeks of training on a slideboard. Ten male subjects ages 19-30 ($x=24 \pm 3$) with an above average fitness level, volunteered to participate in this study. The subjects completed a max VO2 treadmill test, strength and endurance tests of knee extension/flexion, hip extension/flexion, and hip adduction/abduction, and skinfold tests for body composition pre and post training. A one way repeated measures analysis of variance (ANOVA) showed significant increases in maximum heart rate (192.9 bpm vs 195.7 bpm, $p=.006$). Left leg flexion endurance also significantly increased following the training (5.0 sec vs 6.2 sec, $p=.0181$). There was no significant differences found in any of the other variables measured. For individuals with an above average fitness level between the ages of 19 and 30, a seven week training program using a slide board with the same intensities and durations used in this study did not cause significant changes in cardiorespiratory fitness level or strength and endurance measurements with the exception of left leg flexion endurance.

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I would like to thank my mother and father for their support throughout my two years of graduate school, without their help and guidance I would not have been able to achieve my goals. They have always supported my decisions to continue on with my education and have been wonderful parents throughout my life, I love them very much. I would like to thank my sisters Jodi, Molly and Ellie. They have been terrific sisters and I always enjoy time spent with them. I would also like to thank my grandparents for being great inspirations to always work hard and never give up. I would like to thank the lord for watching over me, you are number one.

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CHAPTER 1

INTRODUCTION

Slideboards (figure 1) are an exercise device which requires the exerciser to simulate a skating motion by sliding laterally back and forth. Slideboards are becoming an increasingly popular mode of exercise. Many health clubs and YMCA's are using sideboards in classes as well as having the equipment available for general use. The slideboard provides a portable, easy to use, inexpensive exercise device which allows for variation in exercise and an apparent excellent aerobic workout. It is a functional training device that is becoming a popular addition to conditioning and rehabilitation programs (Reese and Lavery, 1991).

During the 1950's slideboards were designed for use by Olympic skaters (Perkins, 1990). Originally constructed with wood, recent models have a six- to ten-foot by two foot polyethylene sliding surface with hardend rubber bumpers on each end to absorb the necessary force for training (Perkins, 1990; Osbourne, 1990). Special shoe covers, made usually of nylon or wool, are used to reduce friction and improve ease of movement (Reese and Lavery, 1991). The shoe covers are placed over the shoes before exercising.

Slideboards incorporate an integral skill of many sports: lateral agility and power. Slideboard exercise requires the use of the hip adductors and abductors (Reese and Lavery, 1991). However, these are not the only muscles involved during a slideboard workout. In one EMG study it was shown that the

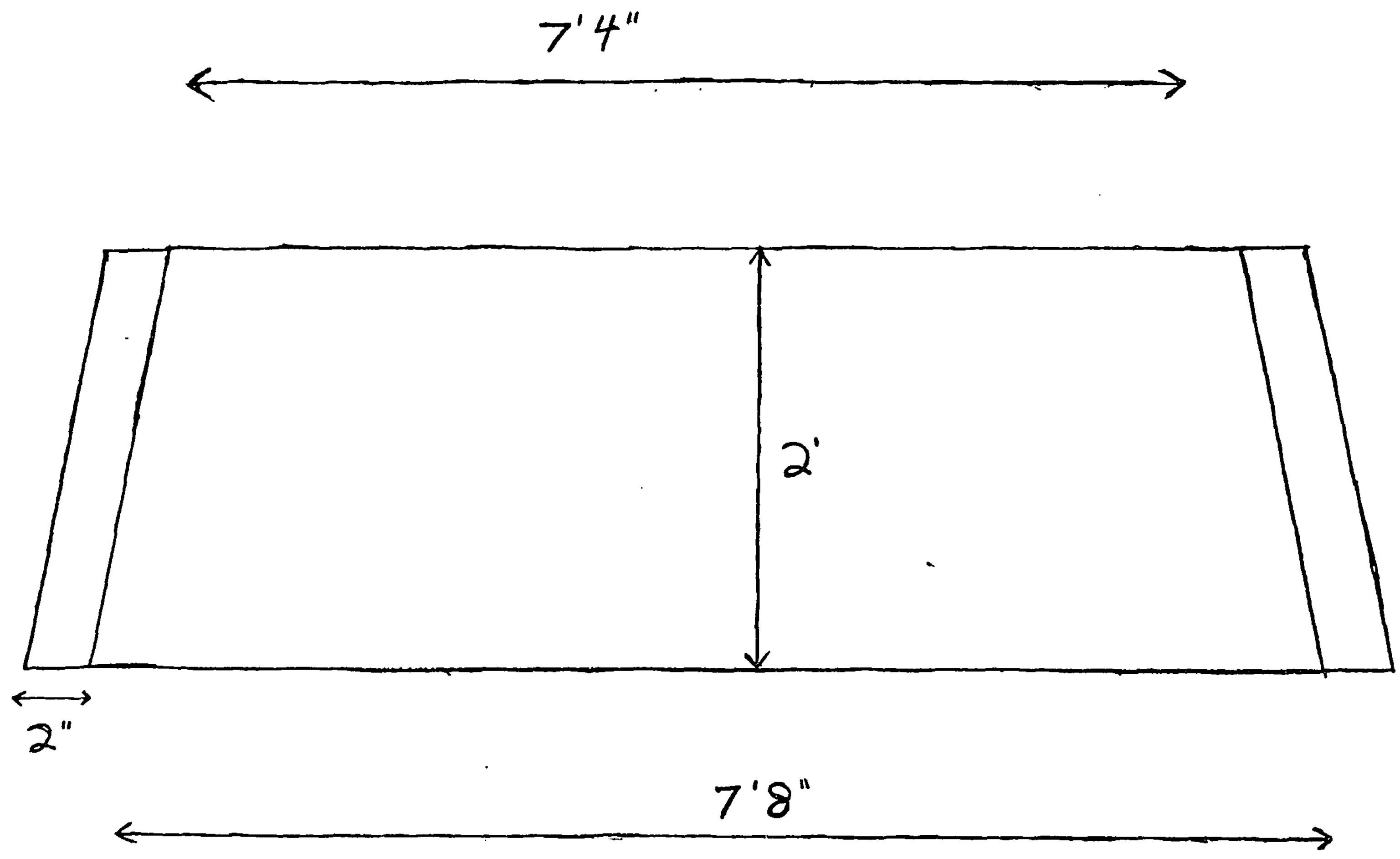

FIGURE 1 SLIDEBOARD DIMENSIONS

quadriceps and hamstrings work almost continuously through the push-off and glide phases of the movement (Perkins, 1990). As in many sport activities the types of contraction vary, between concentric, eccentric, and static (Reese and Lavery, 1991).

Although designed for skaters and hockey players, athletes in basketball, football, volleyball, tennis and other sports can benefit from using slideboards (Reese & Lavery, 1991). While the benefit to certain muscle groups is apparent, the slideboards also require the exerciser to maintain the body position throughout the glide phase of the exercise (Reese & Lavery, 1991). This development of kinesthetic awareness helps in all athletic performance (Reese and Lavery, 1991). Slideboards can be used to develop and maintain aerobic conditioning and aid in numerous sport-related skills.

Need for Study

Studies reporting the documented benefits of participating in an exercise program involving the slideboard are limited. It is assumed that the slideboard can provide an excellent aerobic workout and that leg muscles are used in the sliding motion, but the magnitude of improved cardiorespiratory fitness and increase in muscle strength has not been documented. In addition, the optimum length of a training period for change has not been investigated. This study involved seven weeks of exercising on a slideboard three times a week at an intensity of 70 to 85% of VO2 max, for 15 to 30 minutes.

Purpose

The purpose of this study was to determine the changes in leg strength and endurance, VO2, and body composition, during seven weeks of training on a slideboard.

This study measured the changes in quadricep, hamstring, hip adductor and abductor strength and endurance. Cardiorespiratory changes (VO2 max) and body compostition (% body fat) changes were also measured. The pre-experimental measurements were statistically compared to the post-experimental measurements.

Assumptions and Limitations

The following assumptions were made:

1. It was assumed that each subject performed maximally during the pre and post testing.
2. It was assumed that the subjects did not change their diets during the study.
3. It was assumed that the subjects did not engage in more exercise than they were participating in prior to beginning the study.
4. It was assumed that the max VO2 test gave a true max value.

This study can only be compared with other training studies of similar intensity, duration, length, and subject characteristics.

CHAPTER 2

LITERATURE REVIEW

Exercise is an important component in a healthy lifestyle. There are considerable health benefits associated with moderate levels of exercise, although the precise intensity and amount of exercise required for preventing premature morbidity or death is not exactly known (Pate, 1991). However, it appears that many sedentary individuals would be healthier even if they only walked briskly for 30 to 60 minutes every other day (Pate, 1991). There are two major reasons why individuals exercise. First, there is the person who exercises or trains to be able to perform at a high level of efficiency. These are the athletes. They train for performance. Their training is at high intensity, very specific, long duration, and usually year round. Their fitness might be called "athletic fitness or sports fitness".

Secondly, there are everyday adults interested in exercise and fitness for a preventive reason. Primarily, many adults exercise to prevent the onset of coronary artery disease. Their fitness might be called "general physical fitness"(Lamb, 1979). Numerous epidemiological and scientific studies have documented the value of regular exercise, and recommendations to be physically active have been proposed (Pate, 1991).

The principles of designing an exercise program include the mode, intensity, frequency, duration, and progression of the activity. Since most of application of this material is for personal fitness and not athletic fitness, principles will be discussed in this light.

Mode of Exercise

To improve cardiorespiratory fitness, the appropriate mode of activity is important, it is also important that the activity chosen is one that is enjoyed by the participant. Activities that use large muscle groups; that can be maintained for a prolonged period; and are rhythmic and aerobic in nature are usually activities of choice (Pate, 1991; Powers and Howley, 1991). Examples are: running-jogging, walking-hiking, swimming, skating, bicycling, rowing, cross-country skiing, rope skipping, and vigorous endurance games (Pate, 1991; Powers and Howley, 1991; Daub et al, 1983; Golding, 1989; Osbourne, 1990).

Intensity of Exercise

The opinions of experts on the intensity of exercise needed to improve cardiorespiratory fitness is changing. Traditionally it was recommended that fitness intensity should be 70% - 80% of predicted maximum heart rate. With new research (Blair et al, 1992; Paffenbarger et al, 1986) those suggestions have been drastically downgraded. Training effects are seen at intensities as low as 40% VO2 max and 50% of max. heart rate.

Lower intensities may permit more individuals to exercise since the "no pain, no gain" philosophy was detrimental to compliance. Less stress means more pleasant physical activity, which will result in more participation (Pate, 1991; Lamb, 1979; Astrand, 1986; Powers and Howley, 1991; Daub et al, 1983; Golding, 1989).

The intensity required to produce a training effect increases as fitness improves in a training regime. The training load is relative to the level of fitness of the individual (Astrand, 1986)). As one becomes fitter the absolute intensity of

the exercise session needs to be increased in order for further stress to be imposed on the various body systems.

Various techniques can be used to prescribe and monitor exercise intensity. Heart rate, rating of perceived exertion (RPE), and MET level are among the most common. The purpose is to monitor and control the intensity of exercise, in the range determined to be appropriate for the individual, that allows 15 to 60 minutes of activity to be completed.

Another way to determine intensity is to determine maximal oxygen uptake and work at a percent of that value. However, maximum oxygen uptake is not always feasible to measure, but since there is a linear relationship between oxygen consumption (VO2) and work, and a linear relationship between heart rate and work, heart rate can be used to predict or estimate VO2 (Pate, 1991; Lamb, 1979; Astrand, 1986; Powers and Howley, 1991; Golding, 1989). Intensity can then be given as a percentage of the predicted Max VO2.

Duration of Exercise

The cardiorespiratory period, exclusive of warm-up and cool-down, may vary in length from 15 to 60 minutes (Pate, 1991; Lamb, 1979; Astrand, 1986; Powers and Howley, 1991; Reese and Lavery, 1991; Daub et al, 1983; Golding, 1989; Greer et al, 1992). Most typically the cardiorespiratory (aerobic) phase is 20 to 30 minutes. This duration is required to improve or maintain aerobic capacity. The duration of the cardiorespiratory period is inversely related to the intensity of the exercise (Pate, 1991). Significant cardiovascular improvements have been obtained with aerobic exercise sessions of 5 to 10 minutes' duration with an intensity of more than 90% of functional capacity (Pate, 1991). However, high intensity-short duration sessions are not desirable for most non-athletic participants and better results are obtained with lower intensities and longer

duration. Such programs are preferred because they may carry lower risk for cardiovascular accidents and/or orthopedic injury (Pate, 1991).

Frequency of Exercise

The frequency of exercise depends, in part, on the duration and intensity of the exercise session. The recommended frequency varies from several short daily sessions, to three to five periods per week according to the needs, interests and functional capacity of the participants (Pate, 1991; Lamb, 1979; Astrand, 1986; Powers and Howley, 1991; Daub et al, 1983; Golding, 1989; Greer et al, 1992). Typically, participants with capacities of more than five METS should exercise at least three times per week on alternate days (Pate, 1991).

Progression of Activity

There is a need for a gradual increase in training load with improved performance (Astrand, 1986). Regular training at a given workload gradually lowers the heart rate. Further training at this workload does not modify the heart rate response. After a period of training on a heavier load, the original workload can then be performed with a still lower heart rate. This adaptation to a given load takes place; in order to achieve further improvement, the training intensity has to be increased (Astrand, 1986).

Regardless of whether training is for cardiorespiratory fitness, strength, or muscular endurance the system must be overloaded (increased work load) in order to achieve gains in performance. Overload refers to the observation that a system or tissue must be exercised at a level beyond which it is presently accustomed in order for a training effect to occur (Lamb, 1979; Powers and Howley, 1991; Golding, 1989). The system or tissue gradually adapts to this overload. This pattern of overload followed by adaptation continues until the system or tissue can no longer adapt (Powers and Howley, 1991).

The training effect allows individuals to increase the total work done per session. In continuous exercise this occurs by an increase in intensity, duration, or by some combination of the two. The most significant training effects may be observed during the first six to eight weeks of the exercise program. The training program may be adjusted as these training effects occur with the adjustment depending on participant characteristics, new exercise test results, and/or exercise performance during exercise sessions (Pate, 1991).

Strength

Muscle strength can be defined as the ability to generate maximal force for a very short duration or for a small number of repetitions (Pate, 1991; Powers and Howley, 1991; Golding, 1989). Static (isometric), isotonic and isokinetic strength is produced by static, isotonic and isokinetic exercises. A static contraction is one in which minimal muscle fiber shortening produces force with no change in the angle of a joint. Isotonic contractions result from muscle fiber shortening causing a joint to move through some range of motion against a resistance. Isokinetic contractions occur as muscle fibers shorten to counteract an "accommodating" resistance developed by an instrument that allows only a constant rate of movement regardless of the force exerted by contracting muscle (Pate, 1991; Lamb, 1979; Astrand, 1986; Powers and Howley, 1991).

In this study isometric strength was used as an evaluation of strength. Six muscle actions (hip extension/flexion, knee extension/flexion, abduction and adduction) were measured before and after the training period. The adaptation of the physiological mechanisms of muscle contraction to exercise training, and improvement of muscle force production, can be related to changes which occur within the muscle and/or the nervous function of muscle contraction (Duchateau and Hainaut, 1984). The power-generating contractile proteins of a muscle can

be augmented by hypertrophy of each single muscle fiber or it has been hypothesized that there could be an increase in the number of muscle fibers (Duchateau and Hainaut, 1984).

Isometric strength can be conveniently measured using a variety of devices, including cable tensiometers, dynamometers and load cells. Unfortunately, measures of static strength are specific both to the muscle group and joint angle involved in testing and, therefore, their utility or extrapolation to describe overall muscular strength is limited. Peak force development in such tests is commonly referred to as a "maximum voluntary contraction (MVC)" (Pate, 1991).

Physiologic responses to isometric exercise differ from those of dynamic (isotonic) exercise in several fundamental ways. First, it is most convenient to quantify the intensity of such exercise as a percentage of maximum voluntary contraction (MVC). In this regard, isometric exertion is primarily anaerobic in nature since oxygen delivery is minimized due to sustained compression of the arterial vessels by muscle contraction. Isometric exercise above about 15% MVC results in complete occlusion of arterial blood flow and leads to muscular fatigue. The time to muscular fatigue is inversely proportional to the percent MVC for a given cross sectional area (Pate, 1991).

Slideboard

Slideboards were designed for use by Olympic skaters during the 1950's (Perkins, 1990). Originally constructed with wood, today's models usually have a six- to 10 foot by two-foot polyethylene sliding surface with hardened bumpers on each end to absorb the necessary force for training. Some units have biomechanically angled padded bumpers that can be adjusted for length, eliminating the need for boards of various sizes. Special boots are used to reduce

friction and improve ease of movement. Although relatively inexpensive there are also models made from 3/4-inch plywood covered with Formica and used with socks, with silicone spray (Reese & Lavery, 1991).

There are very few slide board studies in the scientific literature. The slide board is being implemented by clinicians to be used in rehabilitation following lower extremity injury and/or surgery (Harrelson, 1991). Bergfeld and Anderson (1984) recommended that the slide board be used as a therapeutic rehabilitation modality following anterior cruciate ligament (ACL) reconstruction, since the slideboard simulates the ice skating position with the hips and knees flexed. The quadriceps contraction is avoided in the last few degrees of full extension, thus potentially avoiding intense forces to the healing ACL (Bergfeld & Anderson, 1984).

Slideboard action incorporates a basic skill which is used in almost every sport activity: lateral agility and power. However, in many strength training programs, the specific muscle groups involved in lateral movement - the hip abductors and adductors - are often neglected. The slideboard uses, trains and strengthens the hip abductors and adductors. Although the hip abductors and adductors are used strongly, these are not the only muscle groups used during the slide board movement. One electromyographic study has shown that the quadriceps and hamstrings work almost continuously through the push-off and glide phases of the movement (Perkins, 1990). Upon electromyographic studies, Bergfeld and Anderson (1984) confirmed the contraction of the hamstring muscles in a deceleration fashion as the knee approached full extension, and relative inactivity of the quadriceps muscles. Physiologically, eccentric hamstring use; general proprioception for kinesthetic sense; quadriceps/hamstring alternate contraction; and cardiovascular conditioning appear to be promoted by the use of the slide board (Harrelson, 1991). The type of contraction used will

vary, as in most sporting activities, between concentric, eccentric, and static (Harrelson, 1991).

The exerciser begins with feet together against one of the bumpers. The slide is initiated by pushing off the bumper with enough force to reach the other bumper. As the opposite foot meets the far bumper the hamstrings will contract eccentrically to help slow momentum. The exerciser then pushes off the bumper with the other leg. As the exerciser gains confidence, arm movement can be used to increase speed and strength of slide. Due to the slippery surface, caution should be taken against falls. Normally, once the slideboard exercise is initiated the exerciser tends to look down to receive visual input, however, they should be encouraged to look straight ahead instead of looking down (Harrelson, 1991).

Although originally designed for skaters and hockey players, athletes in basketball, football, volleyball, tennis and other sports can benefit from using the slideboard (Reese & Lavery, 1991). The slideboard teaches the exerciser to maintain a balanced body position throughout the exercise. The development of kinesthetic awareness is enhanced through training (Reese & Lavery, 1991). The slideboard will help in the development of muscle strength, power, and endurance, joint proprioception, and allows for the exerciser to exercise on a horizontal plane at comfortable speeds (Harrelson, 1991). Slideboards are simple, portable, affordable and effective. They can be used to maintain aerobic conditioning, develop sport-related skills or redevelop neurological components of physical activities. The variety of athletic skills to which the slideboard relates, and the simplicity of the motor skills needed to perform the exercise, make it a useful part of any conditioning and rehabilitation program (Reese & Lavery, 1991).

In De Boer et al (1987) study, fourteen well trained speed skaters performed all-out exercise tests during ice speed skating, low walking (walking-

like movement in skating position), and dry skating (side to side deep sitting push-offs). Aerobic exercise intensity during the maximal low walking and speed skating tests was not different, while during the dry skating, lower intensity values compared to speed skating were found. The biomechanical characteristics of low walking and dry skating showed substantial differences from speed skating. It was concluded that it is not possible to justify inclusion of these activities in non-ice period training programs on the grounds of close specificity at least insofar as short and maximal performances are concerned.

Training Studies of Different Modes

There are very few slideboard studies in the scientific literature. However, the training effects that occur with other modalities are well documented.

It may be hypothesized that if certain frequencies, durations, and intensities are used to invoke training effects, then the modality should be insignificant.

Due to the lack of literature on the slideboard, the following section presents studies that used similar frequency, duration and intensity as the present slideboard study and reviews their results.

Hutchinson et. al. (1979) studied the effect of a dry land training program (strength and running) on aerobic capacity of 11 college hockey players between the ages of 18 and 20. Maximal oxygen uptake tests were administered prior to dry land training (T1), post six weeks (T2), and at the end of the hockey season (T3). During the first two weeks, the subjects trained three times a week for a period of 1.5 hours. The first thirty minute period was devoted to flexibility and strength calisthenics exercises. For the next thirty minutes, each subject participated in a series of nine weight training exercises, concentrating on the

legs and upper body. Following the weight training session, each subject ran two miles and progressively increased his running to five miles by the end of the first two week period. The time it took to run the five miles was recorded each day, and the subjects were encouraged to try for a faster time each week. Beginning with the third week, the training sessions were extended to six days a week for one and one-half hours. The flexibility and strength calisthenics exercises were continued each day. Three times a week each subject ran a five-mile cross country course. The time it took to run the course was recorded each day and the subjects were encouraged to try for faster times each week. All subjects participated in the same dry land training program. Evaluation of the data revealed that training resulted in significant changes in Max VO2 between the start and end of dry land training. There was also a significant difference in VO2 max between the end of the six weeks of dry land training and the end of the hockey season. It was concluded that a six-week training program significantly increased aerobic capacity (VO2 max.) in college hockey players and if aerobic capacity is to be maintained during the competitive season, an aerobic training program must be continued throughout the course of the hockey season.

Lieber et. al (1989) compared the effects of run-training and swim-training at similar relative intensities based on a treadmill VO2 max value. Thirty-seven sedentary males, aged 28-35 yr., were either run-trained, swim-trained or served as controls in an 11.5 week training study. Runners and swimmers exercised 60 minutes once a day, three days per week, at a heart rate intensity equivalent to 75% of their treadmill VO2 max. Treadmill maximal oxygen consumption (VO2 max) was measured before and following the training period. All subjects & controls experienced a significant increase in treadmill VO2 max over the 11.5

week study. Runners increased Max VO2 by 28%; swimmers 25%; and controls 5%. There was no significant difference between runners and swimmers.

Daub et al. (1983) conducted a study using 10 members of a university ice-hockey team. The subjects were randomly assigned to one of two groups. The purpose of this study was to investigate the difference between ice-hockey training and a combined ice-hockey & cycling training program. The ice-hockey training consisted of participating in practices and competitions an average of six times per week. The duration of each practice was approximately 90 minutes and consisted mainly of maximal and near-maximal sprints. The ice-hockey/cycling group engaged in an identical program of ice-hockey and also trained on the cycle ergometer at submaximal levels for an additional 30-45 minutes three times per week. Four exercise tests, one maximal and one submaximal cycling and one maximal and one submaximal skating, were performed on separate days prior to and following training. The two maximal tests always preceded the submaximal tests. There was no significant difference in VO2 max following the training programs. It was suggested that given the semi-trained nature of the subjects at the beginning of the study, expectations of large elevations in VO2 max may have been unrealistic because the magnitude of change appeared to associate closely with the initial level of VO2 max. A 5-8% reduction in submaximal VO2 occurred at selected time points during submaximal cycling following training for both groups. It was suggested that the decrease in submaximal cycling VO2 may be attributed to an increased efficiency occurring as a general training effect.

Cox et al, (1986) studied 11 relatively inactive individuals preceding and following an intense endurance training program. The subjects trained 6 days a week for seven weeks, alternating days of running and cycling. A Monark cycle ergometer was used during the cycling exercise. The cycling was done for 40

minutes at 60 rpm and at 85-90% of max cycle ergometer VO2. The workload on the cycle ergometer was increased 11 watts per week to ensure a continually intensified training stimulus. The running portion of the program consisted of running five 5-minute intervals on a 400-m track with a five minute jog recovery between each interval. The runs were designed to elicit VO2 max during each interval. The goal was to increase distance traveled per interval each week. A VO2 max test was performed by each subject two days pre- and post-training on a motor driven treadmill, and one day pre- and post-training on a cycle ergometer. VO2 max increased significantly during both the treadmill and cycle ergometer max tests.

Garber, McKinney, and Carleton (1992) compared the benefits of an aerobic dance program and a walk-jog exercise program using a control group. Sixty apparently healthy individuals volunteered for the study. The subjects were randomly assigned to one of three groups: aerobic dance, walk-jog or control group. The subjects met 50 minutes, three days per week for eight weeks. The exercise sessions for both the aerobic dance and walk/jog groups consisted of 10 minutes of warm-up and stretching, 15-25 minutes of aerobic activity, 10-15 minutes of calisthenics and a five minute cool-down. Exercise intensity was set at the heart rate corresponding to 60-80% of the peak oxygen uptake. Pre and post max VO2 tests were performed on a treadmill. Significant increases in maximal oxygen uptake occurred in both the aerobics and walk-jog group, while no significant change was observed in the control group. Peak heart rate decreased significantly in the aerobics and walk-jog groups but was unchanged for the control group following the treatment period.

Poehlman and Danforth (1991) conducted a study in which they examined the effects of an 8-week endurance training program. The program consisted of cycling three times per week for eight weeks. All subjects began the first week

with exercise designed to generate a net expenditure of 150 kcal at 60% of the maximal VO2. Thereafter, the duration and intensity of the exercise program was incrementally increased, so that by the eighth week all volunteers were exercising at 85% of their VO2 max and expending a net energy expenditure of 300 kcal per exercise session. Training increased VO2 max 14% from 29.2 ml/kg/min to 33.6 ml/kg/min.

A 9-week training study by Holdon et al. (1992) consisted of eight subjects performing 45 minutes of supervised exercise on cycle ergometers on four days/week and one hour of independent cycling on a fifth day each week. By the third week, the supervised exercise consisted of an 8-min. warm-up period at 40% VO2 max, a 20- to 25-min. period of steady-state exercise at 70% VO2 max, a 10- to 12-min period of high-intensity interval exercise (30-120 s) at maximal heart rate, and a two to five minute cool-down period. Training work rates were increased weekly to keep the training intensity at a constant percentage of VO2 max. The heart rate elicited at 70% VO2 max before training was used to maintain exercise intensity at a constant percentage of VO2 max during the training program. Heart rates were monitored at regular intervals during each training session to maintain training intensity at the desired level. VO2 max pre and post training was measured during a progressive cycle ergometer test to exhaustion. Training significantly increased peak VO2 from 2.27 l/min to 2.60 l/min.

Summary

Slideboards are simple, portable and appear to be an effective mode for aerobic conditioning. The leg and hip muscles have been shown to work throughout the slideboard exercise, which may result in the development of muscular strength and endurance. It would appear that if the slideboard were

used as an exercise modality and recommended frequencies, duration's and intensities were used, then improvements in fitness would occur.

CHAPTER 3

METHODS AND PROCEDURES

Subjects

The subjects were ten moderately active, healthy male volunteers between the ages of 19 and 30 (X=24, SD=3). Each subject completed an informed consent and Par Q before participating in the study (Appendix I). The study had been approved by the University's Bio Medical Human Subjects Review Board. The physical characteristics of the subjects are present in tables 1 & 2.

Research Design

The research design for the study consisted of three phases.

1. Phase one was the initial testing period. The subjects were tested for muscular strength, muscular endurance, maximum oxygen consumption, and body composition.

2. Phase two consisted of the seven weeks of training. The subjects were required to exercise three times per week. The duration of the exercise session during the first week was 15 minutes, and duration increased five minutes every week until at four weeks, 30 minutes per session was reached. Thirty minute exercise sessions were maintained for the final three weeks. The subjects were fitted with Vantage heart rate monitors before each exercise session to monitor the work intensity. During the first four weeks, the subjects exercised at the heart rate in which 70% of maximum oxygen consumption (max VO2) was

TABLE 1: Subject Characteristics

Subjects	Age	Height (cm)
1	23	182
2	27	175
3	19	183
4	19	175
5	23	179
6	24	175
7	30	173
8	25	175
9	24	178
10	25	175
Mean	24	177
Standard Deviation	3.14	3.37

TABLE 2: Pre and Post measurement of experimental subject means.

Variables	Pre-test Mean±S.E.	Post-test Mean ± S.E.	p
Max VO2 (ml/kg/min)	53.6±1.8	51.8±1.8	.2889
Max HR (bpm)	192.9±2.3	195.7±3.1	.0006*
Weight (kg)	81.0±3.3	80.0±3.3	.2987
% Bodyfat	18.8±1.8	18.1±1.7	.2848

* Pre and post training was significantly different $P < .05$

reached during the max VO2 pre test on the treadmill. During the fifth week, the duration did not increase, but the target heart rates increased to 75% max VO2 then to 80% max VO2 for the final two weeks.

3. Phase three was the post-training testing which was a duplicate of phase one.

Strength and Muscular Endurance

The FARO [1] system was used to measure lower body isometric strength and endurance. The subjects performed Isometric Major Joint Action testing using the Axis Muscle Tester. The testing was performed on a stabilization frame which effectively isolates muscle groups and accurately repositions the subject for reliable repeat testing (see figures 2-8).

The Axis Muscle Tester is designed as a multi application strength and endurance tester to be used as an option on the Metrecom Skeletal Analysis System (Instruction Manual, 1991). The Axis Muscle Tester isometric add-on is composed of a seat assembly and loading tower with a pneumatic piston (Instruction Manual, 1991). The basic concept behind the Axis Muscle Tester's Protocols is to give the examiner the ability to define very specific and individual tests to suit particular conditions or populations (Instruction Manual, 1991).

The Axis Muscle Test is assessing muscular strength (maximum effort) and muscular endurance (maintaining contraction). The Major Joint Maximum test was performed by the subject exerting and sustaining a maximal effort as directed by the examiner from a computer prompt on the screen. The computer automatically recorded the maximal force application. If the force applied fell by 20% of the applied maximum, the test was automatically terminated. This was done on the basis that the subject could no longer sustain maximal force and

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[1] "FARO" Faro Medical Technologies, Inc. and Faro Medical Technologies (U.S.), Inc.

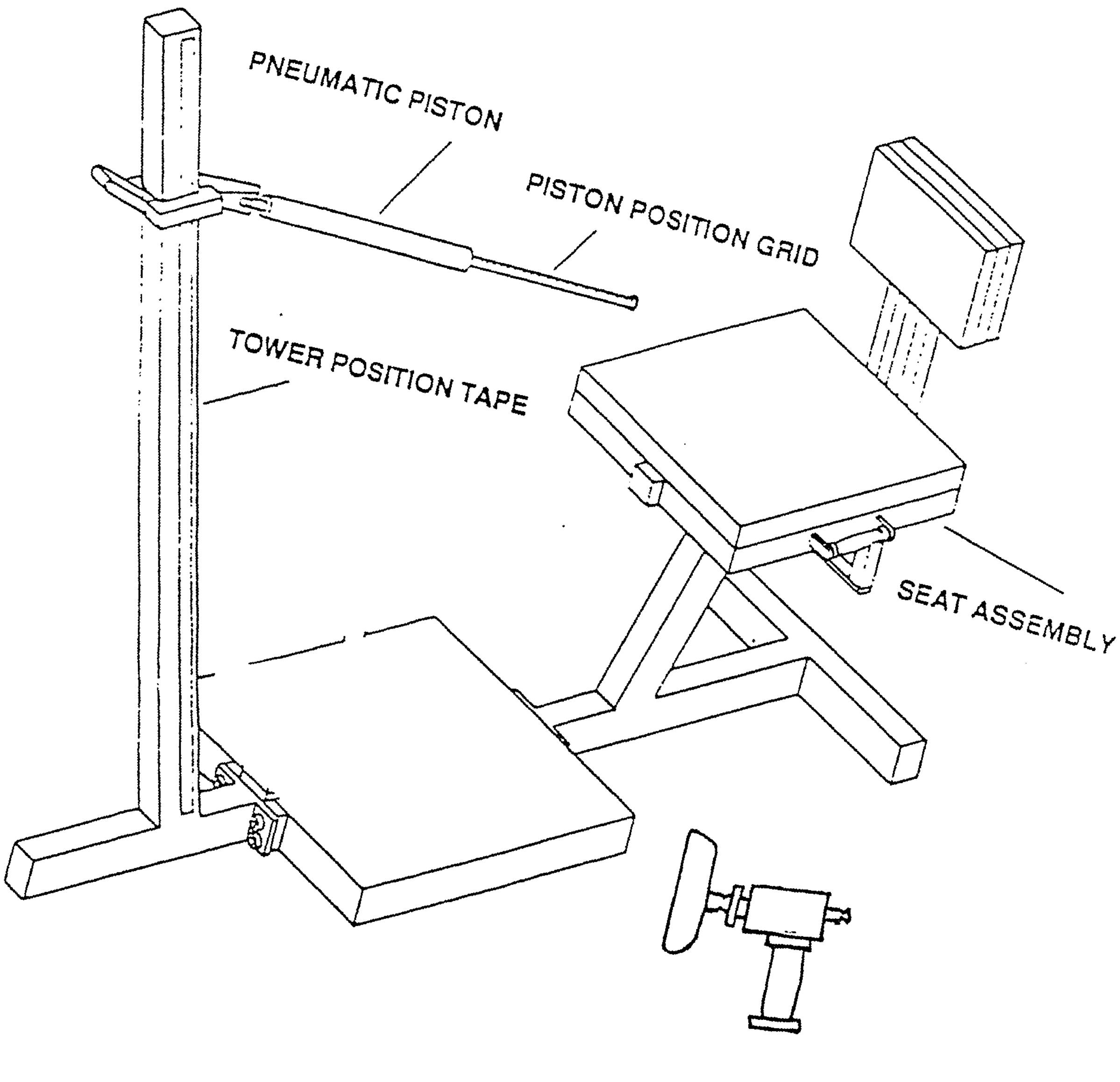


FIGURE 2 FARO AXIS MUSCLE TESTER

therefore had reached the limit of their endurance capabilities so the test was terminated to protect from over-exertion. (The muscle endurance can be recorded by the amount of time it takes for the subject to fall 20% from maximum applied force.)

Major Joint Action tests allow the examiner to evaluate the strength of muscle groups dedicated to specific actions. This study compared pre and post measurements of muscle strength and endurance in the following muscle groups: quadriceps, hamstrings, hip adductors, and hip abductors.

The examiner had the choice of up to three efforts per action. The graphical representation as well as the on-screen reporting of results for each action provided for complete and easy-to-read reports.

Test results are presented in terms of percentage deficits between the two sides (if applicable). The involved side is indicated and the data is presented in terms of average maximum strength for each side with its coefficient of variation (COV), the average Max-20% time of the test for each side with its COV, and the percentage side to side difference are also presented (Instruction Manual, 1991). The Coefficient of variation is a measure often used to describe the amount of variation in a population (Ott, 1993).

The testing was started with the subject placed in position to allow for the measurement of a certain muscle group. The examiner followed the step-by-step screen prompts to proceed with the testing. All the commands were responded to by either the keyboard or switches. The examiner had the option to select this first joint action and proceed with the test by pressing a switch, or to skip this joint action and proceed to the next one by pressing another switch (Instruction Manual, 1991).

The examiner was prompted to enter the tower and cylinder position that is used for that particular test so that the test could be reproduced in future

testing of the subject. An illustration of the FARO system is provided in Figure 2. The tower allowed for vertical movement of the cylinder, and the cylinder allowed for the adjustment of the force pad to the proper position to enable the applied force to be at a ninety degree angle of rotation into the force pad. These may be read directly off both the tower and cylinder shaft. Upon striking either for "no" to modify tower/cylinder position or after modifying the cylinder position, the actual test begins. Each test automatically terminates itself if the applied force drops by 20 percent of the maximum force achieved. This will only occur after the five second mark. For example, if the subject applied a maximum of 100 lbs and decreases to 80 lbs, the test will stop itself, but only if this occurs after the test has been running for five seconds. The examiner may terminate the test by pressing a switch at any point during the test. Each joint action may be repeated up to three times and once these are finished the examiner has the option to do the contralateral side, if applicable (Instruction Manual, 1991).

The 2-5 AVG (average of force exerted from 2 to 5 seconds) as well as the coefficient of variation (COV) for the left and right side are presented along with the graphical force curves following termination of that joint action test. Side to side differences are also presented to allow for easier data interpretation (Instruction Manual, 1991).

Hip extension/flexion, knee extension/flexion, hip abduction, and hip adduction isometric strength were measured and recorded. The subject repeated each muscle contraction three times and the computer provided an average peak force. These movements were done by both the right and left legs. The subjects were instructed to give an all out maximum effort during the tests until the computer acknowledged a decrease in peak force of 20%. The strength and endurance recording form is presented in Appendix II.

Hip Extension/Flexion

The same position is used for both hip extension and hip flexion. The subject was strapped securely around the waist to the support on the apparatus while standing on the platform. The force pad was secured with velcro straps behind the upper knee with the hip flexed 20 degrees. The cylinder and tower were adjusted to a position which allowed for a 90 degree angle of rotation into the cylinder. The cylinder and tower positions were recorded so that reliable repositioning could take place during the post test.

During the extension, the subject pushed the leg back into the cylinder, and was instructed not to push against the apparatus with the hands or feet. To guarantee this the hands were placed across the subject's chest. When the subject was told to push, the foot was raised slightly from the platform so it could not push off the platform (see figure 3).

During the flexion, the subject was in the same position as extension. The subject raised the leg forward, pulling on the force pad. Again the subject was instructed not to use the foot to push off the platform or use the hands to pull against the apparatus (see figure 4).

Knee Extension/Flexion

The subject sat in the seat, and was securely strapped into the chair with velcro straps around the waist and above the knees. The angle of the knee was set at 60 degrees. The tower and cylinder were adjusted so that the subject would be pushing/pulling at a rotation angle of 90 degrees.

During knee extension, the subject pushed against the force pad while grasping the handles provided on each side of the chair (see figure 5).

During knee flexion, the subject pulled away from the force pad (see figure 6).

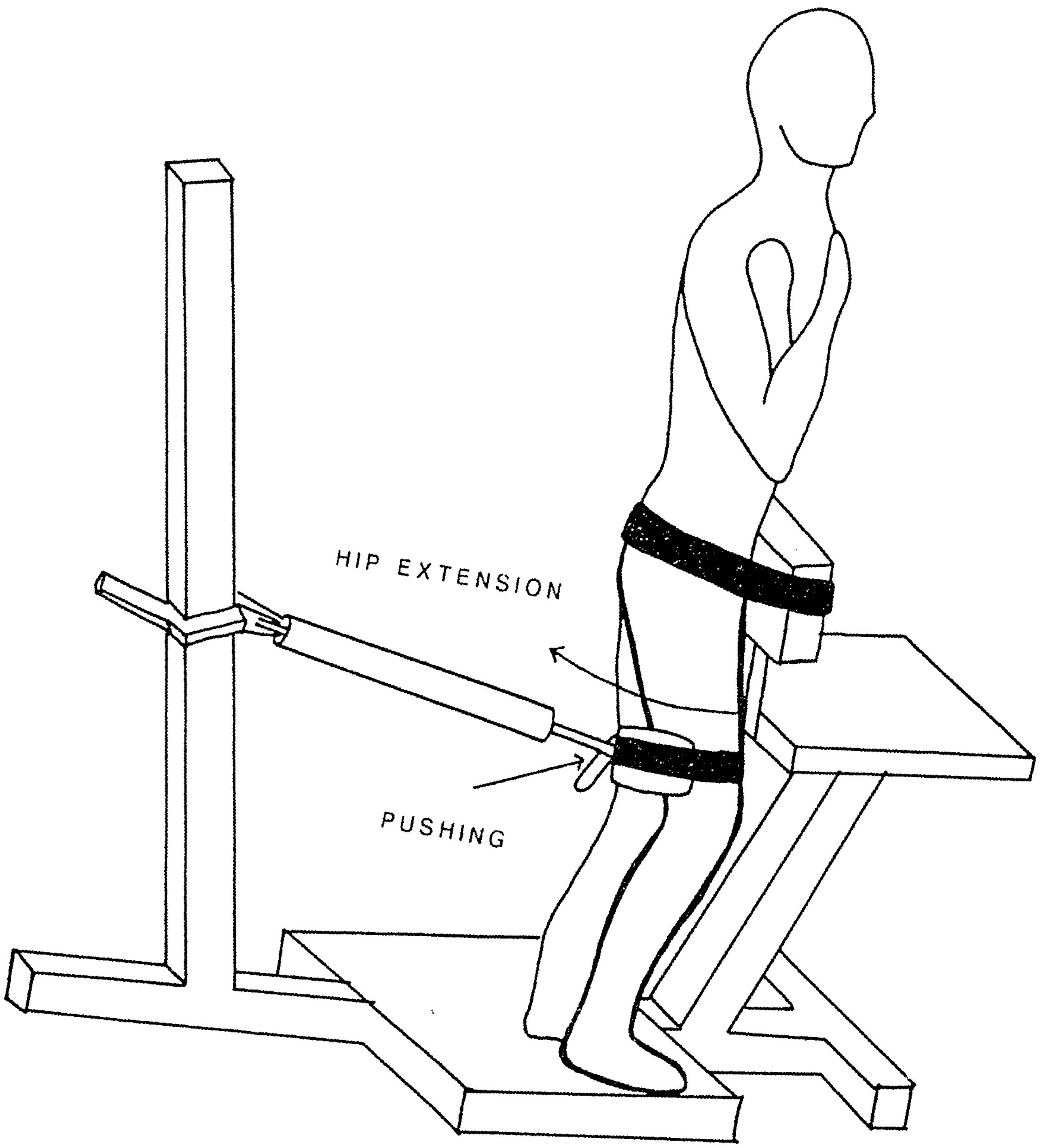


FIGURE 3 HIP EXTENSION

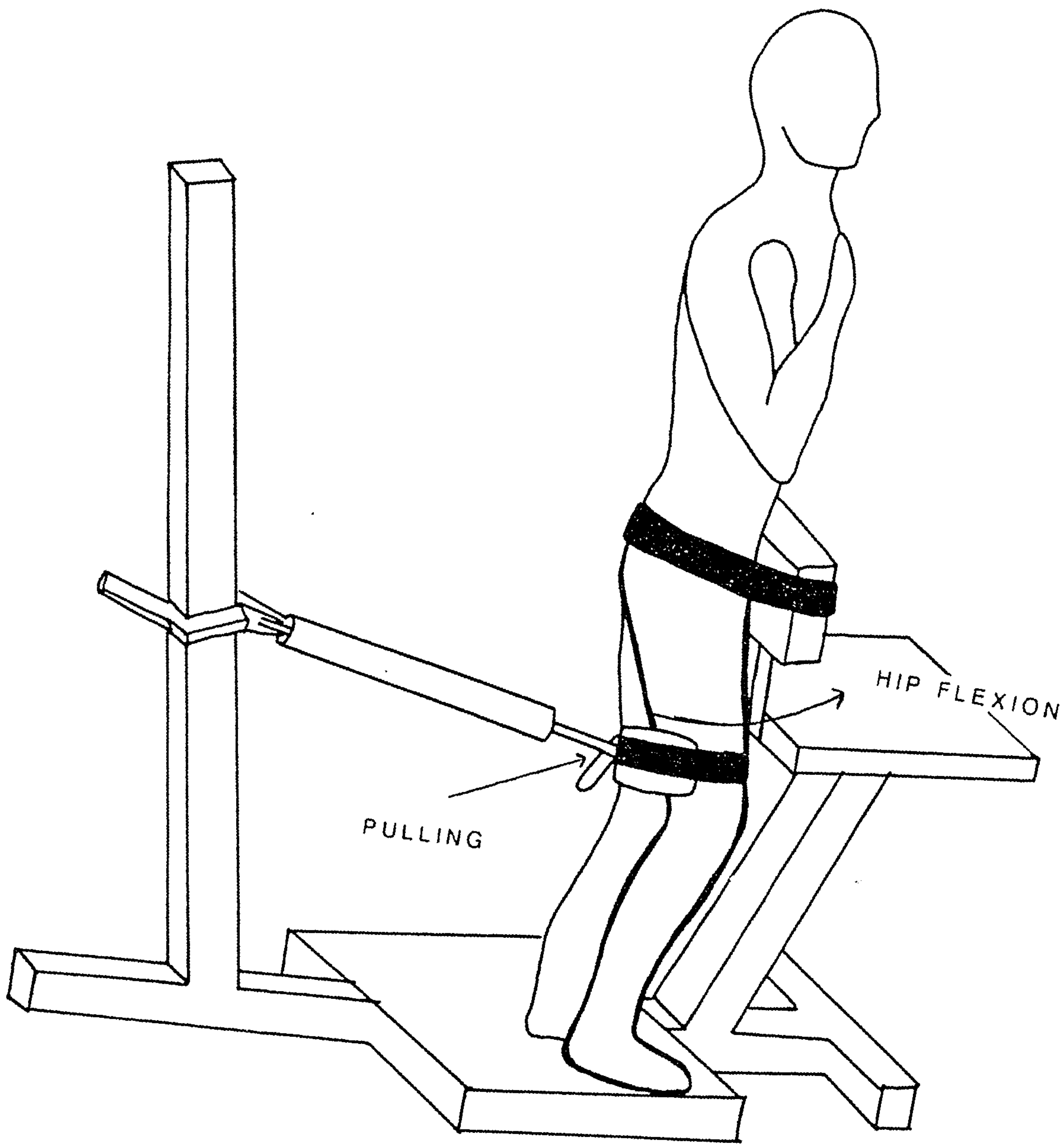


FIGURE 4 HIP FLEXION

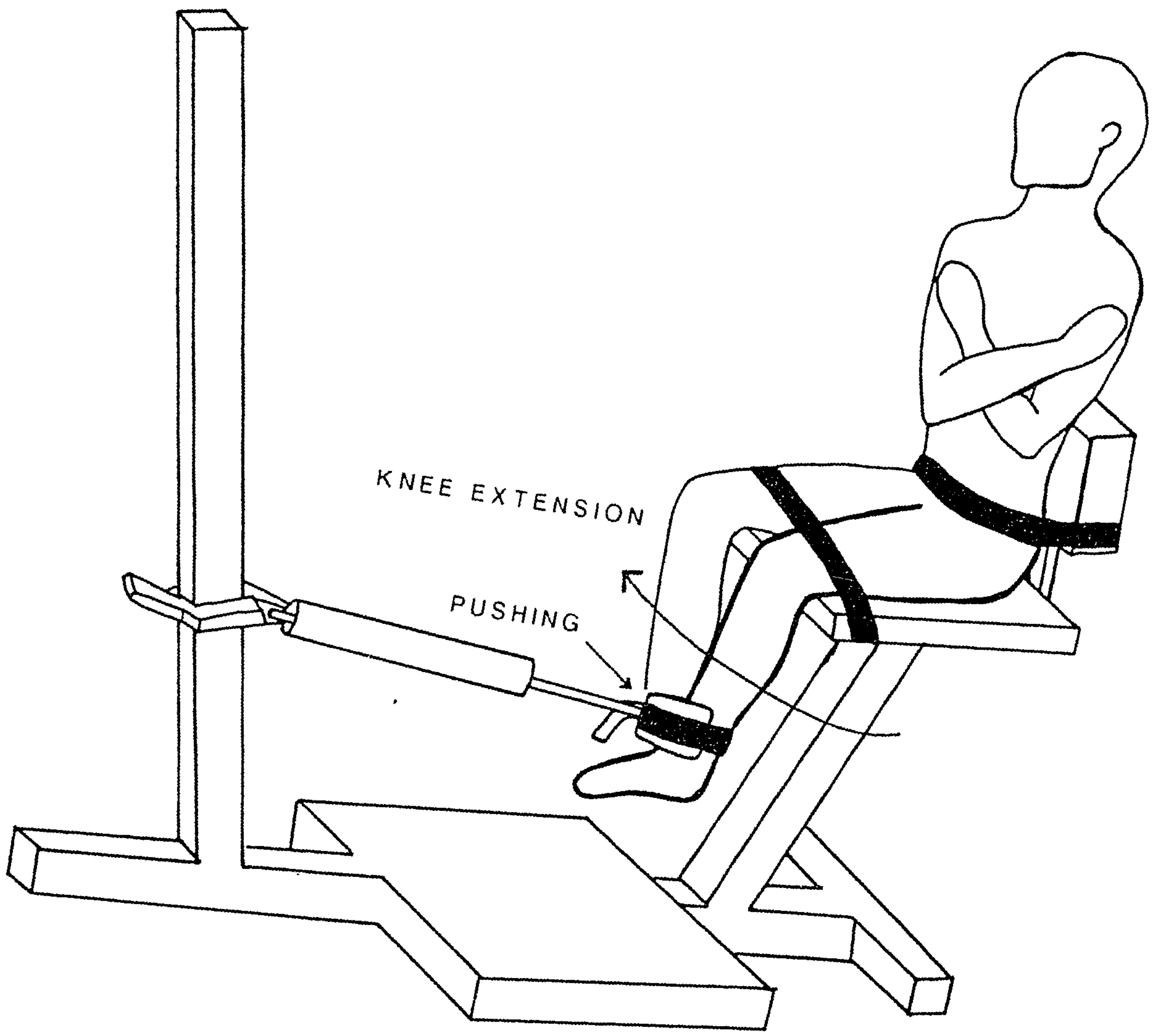


FIGURE 5 KNEE EXTENSION

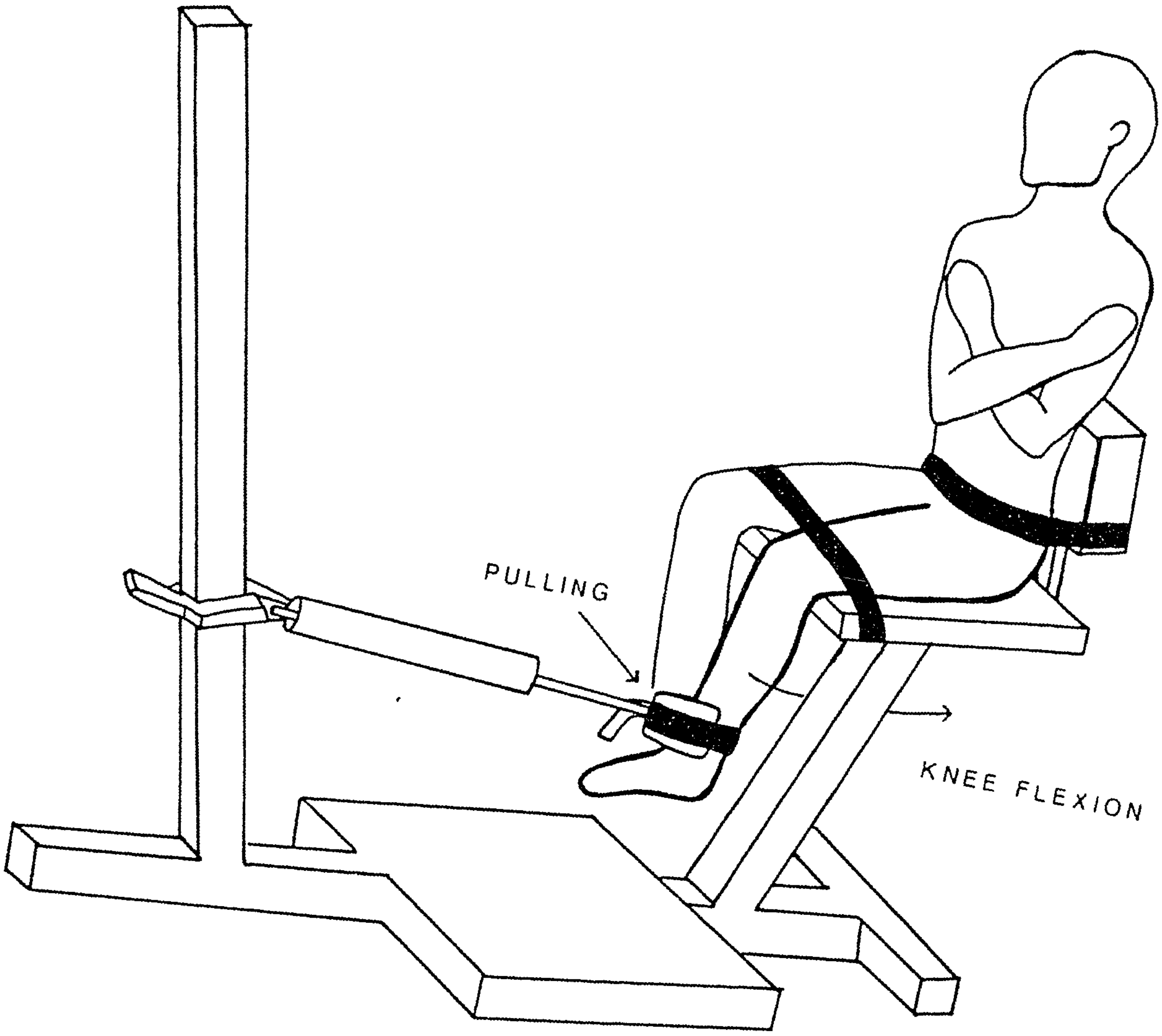


FIGURE 6 KNEE FLEXION

Hip Abduction/Adduction

The subject was strapped securely to the apparatus exposing the side of the knee to the force pad on the cylinder. The force pad was secured to the outer knee with a velcro strap. The subject placed one foot on a plate on the platform, and placed the other foot on a line on the platform.

During hip abduction the subject pushed into the force pad placed on the lateral side of the knee just above the knee. With hands held across the chest (see figure 7).

During hip adduction the subject pulled the knee in toward the median plane of the body (see figure 8).

Maximum Oxygen Uptake

A pre and post maximum oxygen uptake (max VO2) test was completed. Maximum oxygen uptake is the maximum amount of oxygen that can be transported to the body tissues from the lungs per minute. (Golding, 1989). Max VO2 was measured by open circuit spirometry using the Vista metabolic measuring system. Heart rate was measured using Vantage heart rate monitors. Prior to the tests the subjects practiced mounting and dismounting the treadmill and familiarized themselves with running on the treadmill. The protocol consisted of the subjects running at six mph with the grade increased 3% every three minutes (see Appendix II for test protocol). VO2 and heart rate (HR) were recorded every thirty seconds and rating of perceived exertion (RPE) was recorded every three minutes throughout the test. The test was continued until the subject was exhausted and/or indicated that he could not continue.

Percent Body Fat

In order to describe the subject's body composition, percent body fat was estimated by the Jackson and Pollock sum of four skinfolds equation (Jackson &

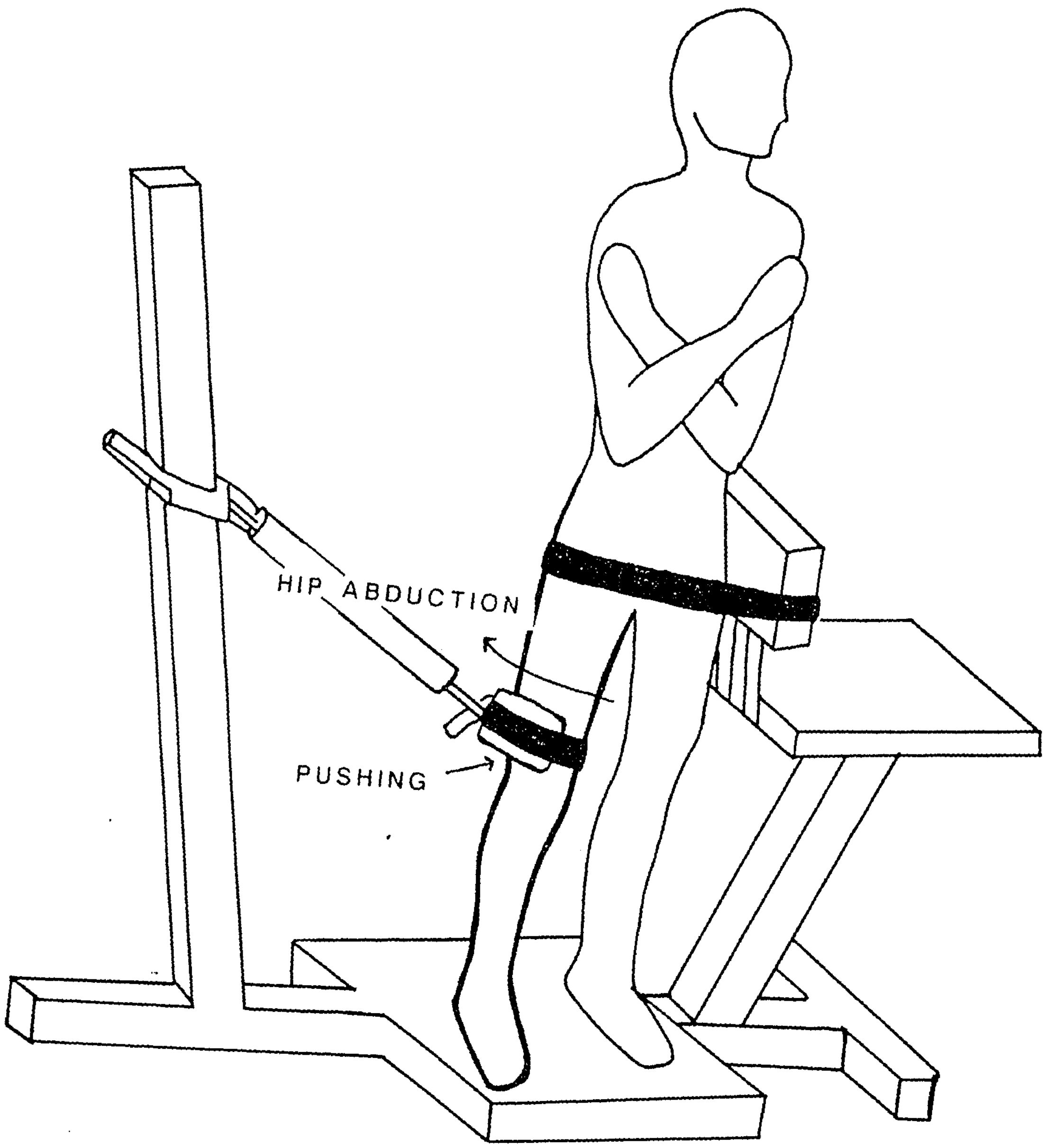


FIGURE 7 HIP ABDUCTION

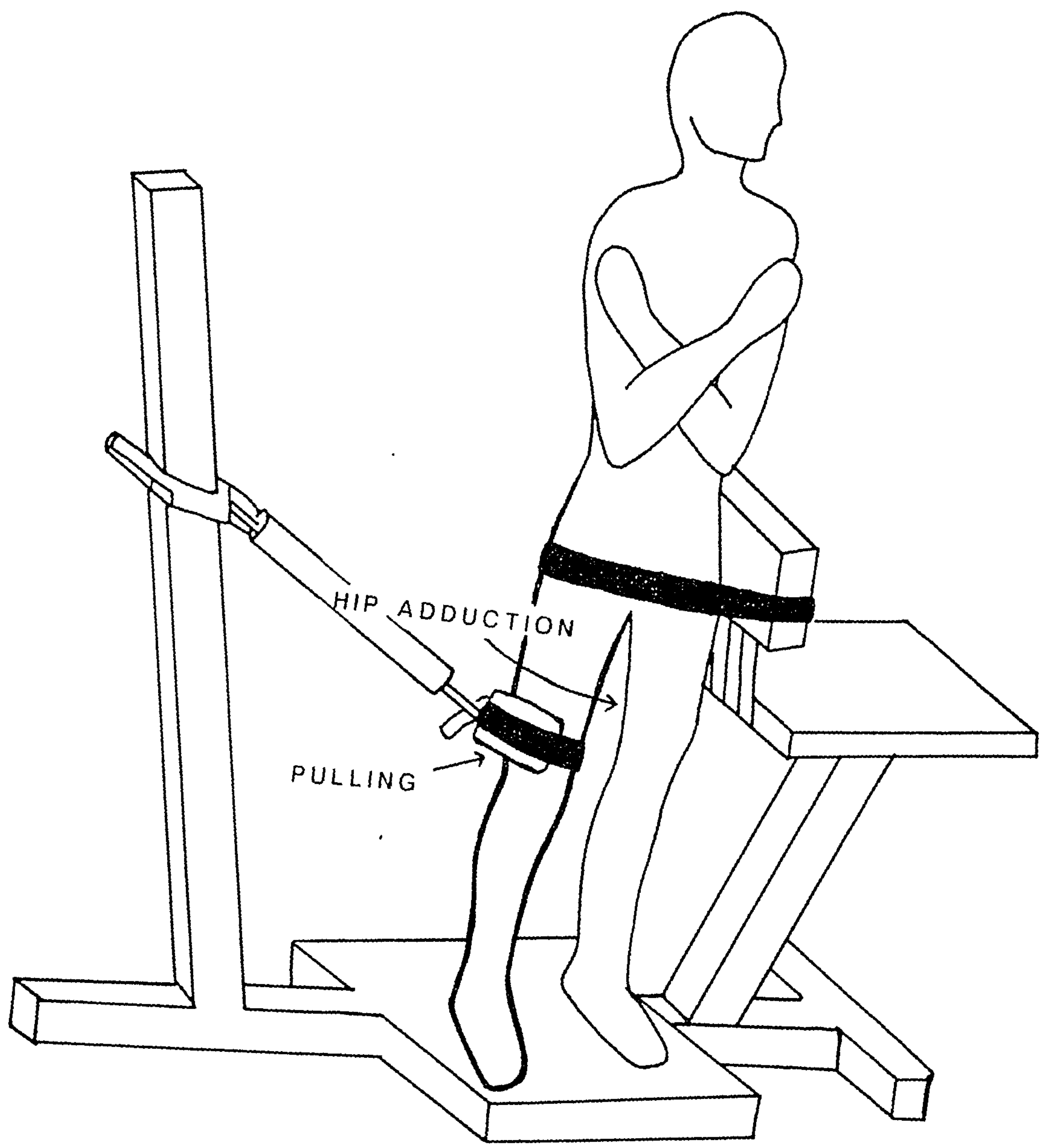


FIGURE 8 HIP ADDUCTION

Pollock, 1978) (Appendix III). Skinfold measurements taken by an expert tester and in the exact sites are an excellent estimate of total body fat. The percent fat in the Jackson and Pollock equation correlates .96 with under water weighing. Skinfold measurements are an excellent field test requiring only skinfold calipers, practice and a skilled tester (Golding, 1989). The abdominal, iliac, thigh and tricep skinfold sites were measured according to the method described by Golding (1989). The skinfold recording form is present in Appendix II. The skinfolds were taken using the Harpenden skinfold calipers and measured to the nearest millimeter.

Training Methods

The subjects were instructed on how to use the slide boards. The exercise began with feet together against one of the bumpers. The subject was flexed at the hips, with the center of gravity slightly ahead of the waist. The knees were slightly flexed. A lateral force was applied against the bumper by the adjacent foot, the opposite foot and leg were moved to glide to the opposite bumper. When feet were almost together against the opposite bumper, the movement was performed again by the opposite leg to return to the first bumper. The boards were cleaned and waxed before each exercise session. Booties were provided and worn over the subjects' gym shoes. Target heart rates for each subject were assigned and recorded on an adjacent chalk board each week. The subjects were instructed to keep themselves at the target heart rate during the training session. The heart rate monitors provided information to either increase, decrease or maintain the intensity level of the exercise.

Statistical Design

The pre and post training measurements of leg strength and endurance, VO2 max, percent body fat, and body weight were analyzed by one way repeated measures analysis of variance (ANOVA).

CHAPTER 4

RESULTS AND DISCUSSION

Ten apparently healthy, male subjects averaging 24 (SD 3) years old and with an average height of 177 (SD 3.37) cm volunteered to participated in this study (table 1). The data collected from the study are presented in tables 1-5.

The experimental training period consisted of training three times a week for seven weeks. The duration of the exercise sessions increased five minutes each week from 15 to 30 minutes over the first four weeks, after which the intensity of the exercise was increased during the final three weeks from 70% VO2 max to 80% VO2 max. Table 3 presents the attendance record for each subject, and indicates that attendance was excellent; from the total 21 sessions the average attendance was 19.4 sessions. As in all studies even the conscientious subjects occasionally missed a training session, however, a 92% attendance was considered excellent.

Cardiorespiratory Fitness

All the measured variables were analyzed by a one way repeated measures analysis of variance (ANOVA). The average max VO2 on the pre-test was 53.57 ml/kg/min. which was well above the average for 24 years old. National norm tables indicate that a max VO2 of 53.57 ml/kg/min. is at the 75th percentile for 24 year old male subjects, so they were above average in aerobic capacity when the study was started. After the seven week experimental period the average max VO2 was 51.80 ml/kg/min. which is a 1.77 ml/kg/min

TABLE 3: Training period attendance*.

Subject	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	TOTAL
1	3	2	3	2	3	3	2	18
2	2	3	3	3	3	3	2	19
3	3	3	3	3	3	3	2	20
4	3	3	3	3	3	3	2	20
5	3	2	3	2	3	2	2	17
6	3	3	3	3	3	3	2	20
7	3	3	2	3	3	3	2	19
8	3	3	3	3	3	3	2	20
9	3	3	3	3	3	3	2	20
10	3	3	3	3	3	3	3	21
X	2.9	2.8	2.9	2.8	3.0	2.9	2.1	19.4
S.D.	.3	.4	.3	.4	0.0	.3	.3	1.2

*100% attendance would be 3 times per week.

decrease, however, this was not a significant change. Astrand (1986) indicates that during two to three months of training, at 30 min each session, and three times per week, the magnitude of max VO2 change is 10 to 20 percent, but with large individual variations. Since the subjects were above average fitness at the start of the study this may explain the non-significant change in max VO2.

There was a significant increase in maximum heart rate (HR) between the pre and post testing while performing the max VO2 test (p=.0006). The mean max HR's were 192.9 and 195.7 for the pre- and post-test respectively (table 2). According to their max HR's the subjects appeared to give their maximal effort during the post-test since they were slightly above their age-predicted max HR. Maximum aerobic capacity is reached when there is no further increase in oxygen uptake despite further increase in the rate of exercise (Astrand, 1986).

Body Composition

Body weight and percent body fat were recorded partly to see if changes in body composition would occur during the training period, and also to describe the body composition of the subjects. The average percent body fat was 18.8% prior to the training and 18.1% following the training (table 2), the slight decrease of 0.7% is not considered significant. National norm tables indicate that a percent body fat of 18% is at the 40th percentile for 24 year old male subject, so they were considered below average in percent body fat.

The average pre-test body weight of the subjects was 81kg and the average post-test body weight was 80kg (table 2), so changes in percent body fat and body weight were not considered significant. The lack of any significant change in body weight or percent body fat was expected. The exercise session represented approximately 225 calories at the beginning of the training to 500 calories at the end of training which translates into 675 to 1500 calories per week.

Since no restrictions were put on the subjects diet, the subjects could have increased their weekly calorie intake by 675 to 1500 calories per week, which would account for lack of weight and/or percent fat changes.

Muscular Strength and Endurance

Slideboard exercise requires the subject to slide laterally back and forth. The subject pushes off one bumper, slides across the board and then pushes off the other bumper in the opposite direction to return to the starting bumper; this is done continuously. The slide is initiated by pushing off the bumper with enough force to reach the other bumper. The push results in an isotonic contraction of the knee and hip extensors. An isotonic contraction is one in which the muscle shortens when inervated producing a given force (Astrand, 1986). When the opposite leg and foot arrive at the other end of the slideboard, the same muscles (knee and hip extensors) eccentrically contract to help slow momentum and allow the knee and hip to bend in preparation for the push-off once again. It appears that knee extension and hip extension are used both concentrically and eccentrically at each end of the board. In dynamic exercise, the muscle may shorten, in which case the work is called concentric contraction, or the muscle may lengthen, in which case the work is called eccentric contraction (Astrand, 1986). It would appear that these muscle groups because of their use, would increase in strength. The results of this study indicate that no significant strength or muscle endurance changes were found in right or left leg knee extension or in right and left hip extension (tables 4 & 5) (figures 9-12). The lack of any significant changes in leg or hip extension was not expected since an electromyographic (EMG) study had shown that quadriceps and hamstrings work almost continuously through the push-off and glide phases of the movement (Perkins, 1990). The lack of significance may be due to the lack of

TABLE 4: Isometric Strength (lbs.)

Variables	Pre-test Mean±S.E.	Post-test Mean±S.E.	p
RLF	73.0±4.4	69.8±4.2	.4718
LLF	70.1±1.6	66.4±4.3	.3935
RLE	153.7±6.3	139.5±7.4	.1313
LLE	140.0±7.5	143.5±7.4	.6473
RAB	78.5±3.07	82.0±4.07	.2789
LAB	76.3±3.5	85.8±4.3	.0545
RAD	83.8±3.4	94.8±6.4	.0655
LAD	82.3±5.4	91.2±6.5	.0734
RHF	103.8±7.8	105.4±6.2	.7037
LHF	108.6±6.1	110.1±7.1	.7534
RHE	108.8±6.9	112.0±10.4	.7124
LHE	102.2±9.9	110.1±9.7	.3818

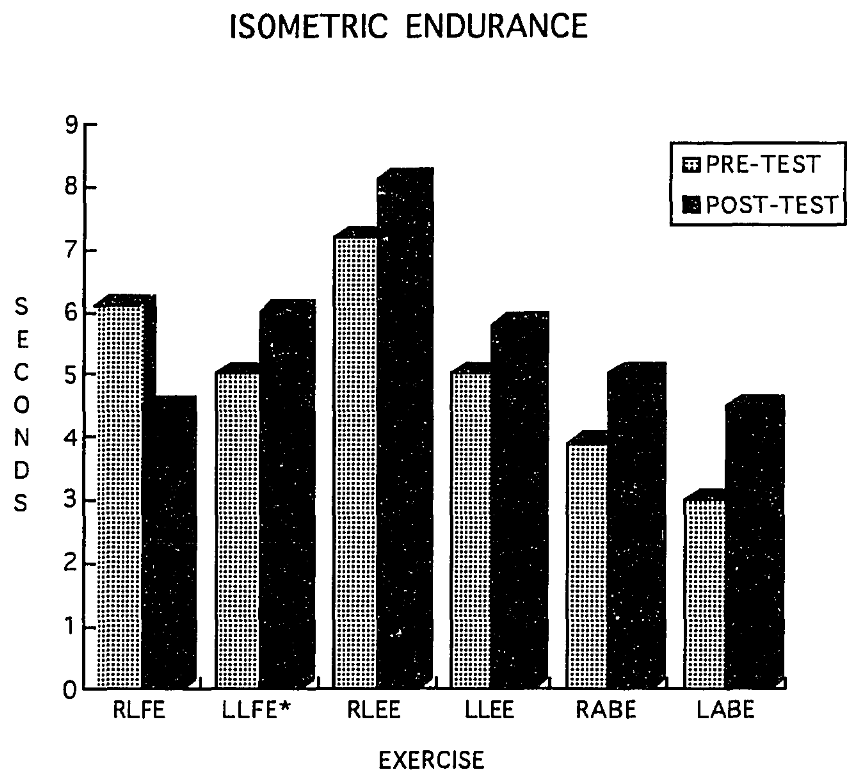
RLF-Right Leg Knee Flexion
LLF-Left Leg Knee Flexion
RLE-Right Leg Knee Extension
LLE-Left Leg Knee Extension
RAB-Right Hip Abduction
LAB-Left Hip Abduction
RAD-Right Hip Adduction
LAD-Left Hip Adduction
RHF-Right Leg Hip Flexion
LHF-Left Leg Hip Flexion
RHE-Right Leg Hip Extension
LHE-Left Leg Hip Extension

TABLE 5: Isometric Endurance (sec.)

Variables	Pre-test Mean±S.E.	Post-test Mean±S.E.	p
RLFE	6.1±1.3	4.5±.6	.1409
LLFE	5.0±1.6	6.2±.8	.0181*
RLEE	7.2±1.0	8.1±1.4	.3988
LLEE	5.0±.6	5.8±.8	.4280
RABE	3.9±.8	5.0±.9	.3214
LABE	3.0±.3	4.5±.7	.0522
RADE	4.5±.8	4.2±.7	.6470
LADE	3.5±.9	3.0±.7	.3434
RHFE	3.7±.9	4.2±.6	.5571
LHFE	3.7±1.0	4.1±.8	.6255
RHEE	2.5±.8	2.9±.9	.7163
LHEE	2.3±.4	2.5±.4	.7640

RLFE-Right Leg Knee Flex. End.
LLFE-Left Leg Knee Flex. End.
RLEE-Right Leg Knee Ext. End.
LLEE-Left Leg Knee Ext. End.
RABE-Right Hip Abd. End.
LABE-Left Hip Abd. End.
RADE-Right Hip Add. End.
LADE-Left Hip Add. End.
RHFE-Right Hip Flex. End.
LHFE-Left Hip Flex. End.
RHEE-Right Hip Ext. End.
LHEE-Left Hip Ext. End.

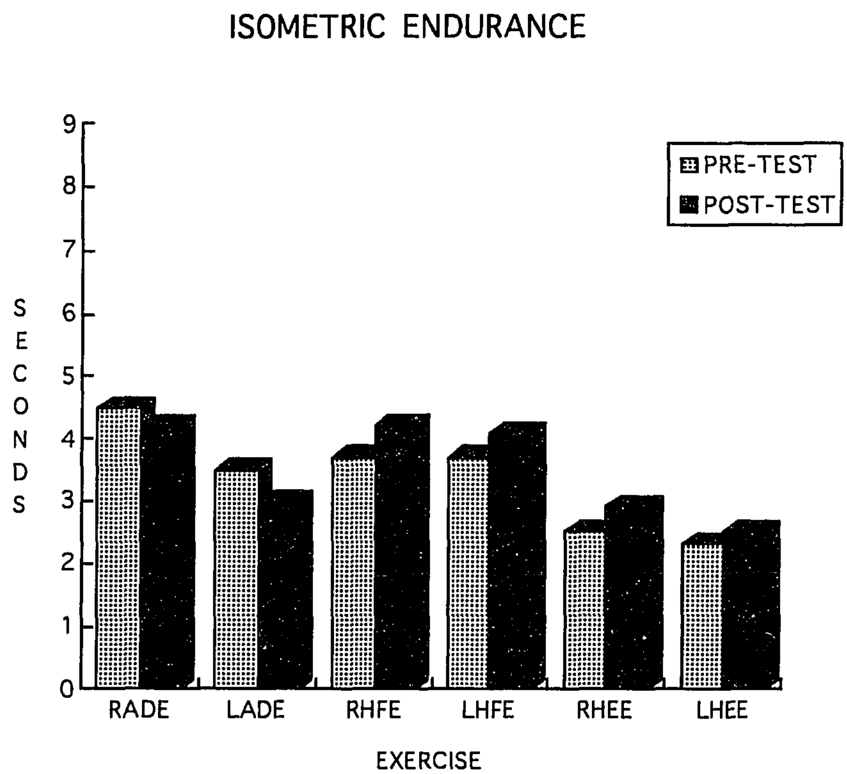
* Pre and post training was significantly different P < .05



*significantly different

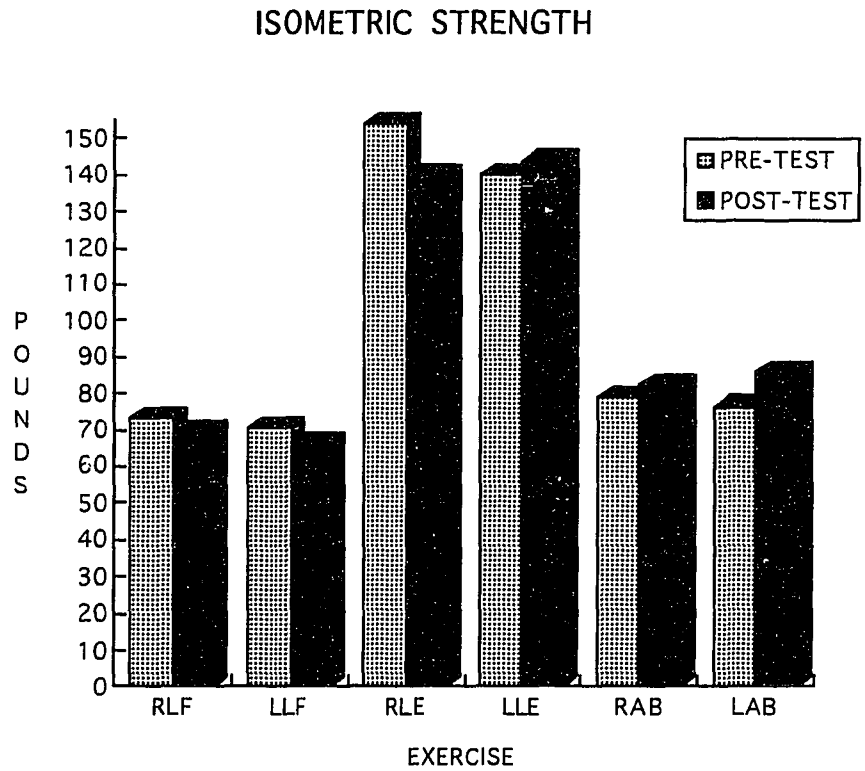
RLFE- Right Leg Knee Flexion Endurance
LLFE- Left Leg Knee Flexion Endurance
RLEE- Right Leg Knee Extension Endurance
LLEE- Left Leg Knee Extension Endurance
RABE- Right Hip Abduction Endurance
LABE- Left Hip Abduction Endurance

FIGURE 9: Isometric endurance for leg exercises.



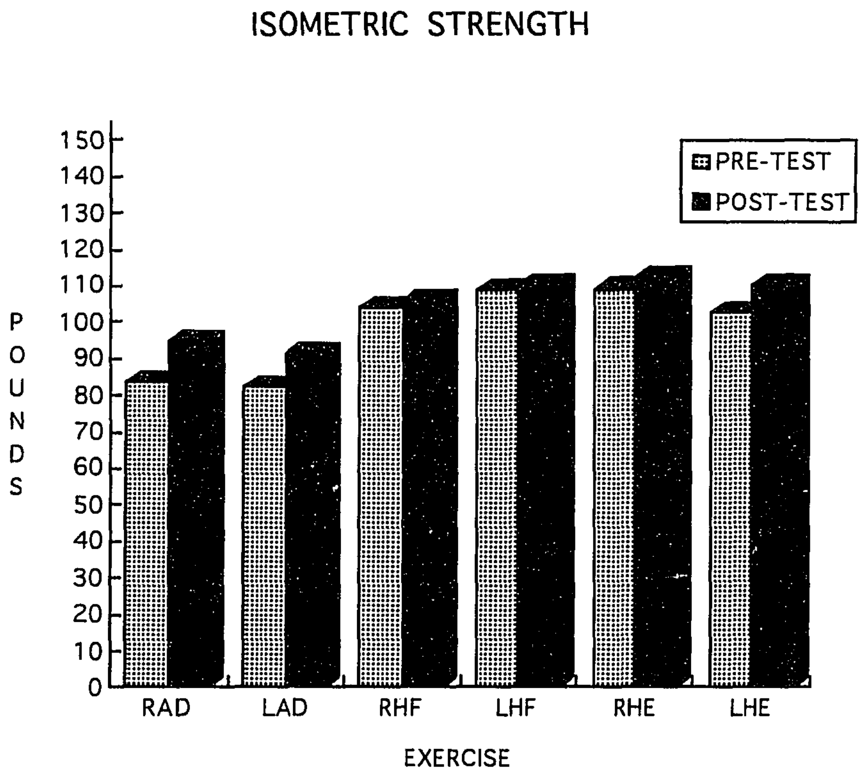
RADE- Right Hip Adduction Endurance
LADE- Left Hip Adduction Endurance
RHFE- Right Hip Flexion Endurance
LHFE- Left Hip Flexion Endurance
RHEE- Right Hip Extension Endurance
LHEE- Left Hip Extension Endurance

FIGURE 10: Isometric endurance for leg exercises.



RLF- Right Leg Knee Flexion
LLF- Left Leg Knee Flexion
RLE- Right Leg Knee Extension
LLE- Left Leg Knee Extension
RAB- Right Hip Abduction
LAB- Left Hip Abduction

FIGURE 11: Isometric strength for leg exercises.



RAD- Right Hip Adduction
LAD- Left Hip Adduction
RHF- Right Hip Flexion
LHF- Left Hip Flexion
RHE- Right Hip Extension
LHE- Left Hip Extension

FIGURE 12: Isometric strength for leg exercises.

overload of the relatively large muscle groups being used. The only resistance throughout the training period is the body weight of the subjects. Also the relatively short duration of the study and the pre-training fitness levels of the subjects may have contributed to the lack significance..

Slideboards incorporate movement which is an integral part of almost every sport activity: lateral agility and power (Reese, 1991). The hip adductor and hip abductor muscle groups are involved in lateral movement (Reese, 1991). The hip adduction occurs when the leg is moved towards the midline of the body (Hole, 1990). The hip abduction occurs when the leg is moved away from the midline of the body (Hole, 1990). By using the slideboards, the hip adductors and abductors are directly involved in the training program. It appears that during the push-off phase of the movement, the hip abductors help produce a force against the bumper to force the body in the opposite direction and during arrival of the leg into the bumper, the hip adductors and abductors help absorb the shock and slow down the momentum of the movement in order to prepare for movement in the opposite direction. Due to the fact that the subjects in this study had never participated in a slideboard training program before where lateral movement is the major component of the exercise, a significant increase in hip adduction and hip abduction were expected to occur. In addition, the abductor and adductor muscles of the hip are also flexors and extensors of the hip so they are worked both during abduction and adduction and also hip flexion and extension. The results of this study indicate that hip adduction and abduction increased both in strength and endurance as expected, however, these increases were not significant (tables 4 & 5) (figures 9-12). The lack of significance in hip adduction and hip abduction strength and endurance could be due to the relatively short duration of this study. The pre-training fitness levels of the subjects was considered to be above average. The subjects may have engaged in

recreational activities in which lateral movement was performed (i.e. racquetball).

The slideboard simulates the ice skating position with the hips and knees flexed (Harrelson, 1991). It is important that when exercising on the slideboard that the knees and hip remain flexed throughout the movement in order to maintain balance. Electromyographic (EMG) studies have confirmed the contraction of the hamstring muscles in a deceleration fashion as the knee comes closer to full extension during the push-off phase (Harrelson, 1991). Since the body is positioned with the knees and hip flexed throughout the sliding movement it would appear that the antagonists i.e. hip and knee extension strength and endurance would increase over the seven week training period. The results of the knee and hip extension endurance and strength measurements indicate that left leg knee extension endurance was not significantly changed (tables 4 & 5) (figures 9-12). There was a significant increase in left leg knee flexion endurance ($p=.0181$) from 5.0 seconds to 6.2 seconds (table 5) (figure 9). There were no other significant increases found in hip and knee flexion strength and endurance measurements during the post-tests. The lack of significance may be due to the relatively short duration of this study. The subjects were considered to be at an above average fitness level which may have decreased the chances of seeing significant improvements over such a short time. The lack of overload on the muscle groups involved in the sliding motion may explain why significant increases in muscular strength and endurance did not occur.

Muscular strength refers to the maximal force that can be generated by a specific muscle or muscle group (Pate, 1991; Powers and Howley, 1991; Golding, 1989). Muscular endurance is defined as the ability of a muscle group to perform work over a period of sufficient time duration to cause muscular fatigue (Pate, 1991; Powers and Howley, 1991). When the testing involves an isometric muscle

contraction, the timed ability of the subjects to maintain a specific percentage of maximum voluntary contraction is usually measured as an index of muscular endurance (Pate, 1991). During both the pre and post tests the subjects were continuously encouraged to achieve maximum values for muscular endurance and strength. Cooperative and well-motivated subjects can maintain a muscular contraction to the point of muscular fatigue, however, unmotivated subjects terminate the effort before reaching the point of muscular fatigue (Astrand, 1986).

The adaptation of the physiological mechanisms of muscle contraction to exercise training, and improvement of muscular force production, can be related to changes which occur within the muscle and/or the nervous function of muscle contraction (Duchateau and Hainaut, 1984). The power-generating contractile proteins of a muscle can be augmented by hypertrophy of each single muscle fiber or it has been hypothesized that there could be an increase in the number of muscle fibers (Duchateau and Hainaut, 1984). When striving for muscle strength for a particular activity, the best training is training while doing that movement or activity. This is the principle of specificity.

The gain in strength after participating in a training program is due not only to changes in the muscle tissue but also to a modification of the impulses reaching the motor neurons. The neural adaptations to training account almost exclusively for the gains in strength and power observed during the first 6-8 weeks of training, and the improvements during performance of the training task are not transferable to other activities (Mannion et al., 1992). The duration of this training study was seven weeks, so according to Mannion et al. (1992) any strength gains would be due to neurological adaptations. There were however, no significant strength gains found. This could possibly be due to the lack

transferability of improvements from the dynamic training task of slideboarding to the isometric measurement of strength and endurance.

Muscular strength and endurance have little direct relationship to cardiorespiratory fitness (Pate, 1991). However, many leisure and occupational tasks require both cardiorespiratory fitness and muscular strength. The maintenance or enhancement of muscular strength and muscle endurance enables the individual to perform such tasks with less physiological stress. Maintenance of adequate strength becomes an increasingly important issue with advancing age which is associated with a loss of lean weight (Pate, 1991).

This was a seven week training study which measured leg strength and endurance of hip adduction/abduction, hip flexion/extension, and knee flexion/extension; body composition, and maximum aerobic capacity. None of these parameters changed significantly, except for left leg flexion endurance and maximum heart rate. However, the subjects although relatively fit at the start of the study (75th percentile for their age and sex) did find that the exercise sessions got easier and by the end of the study they were able to do the 30 minutes of exercise at 80% of VO2 max with little stress. Krause & Golding (1992) had found that working on the slide board caused the exercise HR to be above 90% of max supporting the fact that slide board activity is a strenuous activity. Other studies working for 15-45 minutes at 70-80% max HR have shown significant changes in aerobic capacity (Garber et al; 1992; Daub et al; 1983).

The lack of change in the parameters measured is difficult to explain since the slideboard exercise was done at a relatively high intensity. It has already, been suggested that the lack of significant change may be due to: 1) the short training period, 2) the relative fitness of the subjects prior to starting, 3) In the case of body composition changes a lack of diet control, and 4) the lack of

overload to the muscle may have decreased the chances of significant increases in strength.

There is another possibility. Max VO2 does not usually change more than 15-20% (Astrand, 1986) and these subjects were already fit.

Beginning level (unfit subjects) have difficulty sliding for even eight min (Krause & Golding, 1992) indicating that 30 minutes of sliding represents significant cardiorespiratory fitness.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to evaluate changes in the muscular strength and endurance of the leg muscles; Max VO2, and body composition, resulting from a seven week training program on a slide board.

The research design consisted of three phases. Phase one was the initial testing period. Muscular strength and endurance of the hip flexion/extension, knee flexion/extension, and hip abduction/adduction were tested. Max VO2 was measured during a graded exercise test. Body composition using the Jackson & Pollack equation and body weight was also measured.

Phase two consisted of a seven week training period. The duration of the exercise sessions began at 15 minutes and increased five minutes each week until a duration of 30 minutes was reached. The intensity of the exercise was at the heart rate in which 70% max VO2 was reached during the max VO2 pre test on the treadmill. During the fifth week, the duration did not increase, but the target heart rates increased to the value at 75% max VO2 then to the value at 80% max VO2 for the final two weeks.

Phase three was the post-training testing which was a duplicate of phase one.

Significant increases due to training occurred in both maximum heart rate achieved during the max treadmill tests and in left leg flexion endurance. The significant increase in max heart rate indicates that the subjects were working harder during the post training max treadmill test, however increases in max

VO2 were not found. The significant increases in left leg flexion endurance indicates that following the seven week training period the subjects were able to maintain a high force output for a longer period of time during isometric left leg flexion. Left leg abduction strength and endurance, and right and left leg adduction strength changed in a direction consistent with predictions but the change was not statistically significant.

Maximum VO2, body weight, and percent body fat did not change significantly after the seven weeks of training on the slide board. No significant increases were found in any of the leg strength and endurance measurements except for left leg flexion endurance.

Conclusion

The results of this study would indicate that the slide board is not an effective training device for improvement in leg strength and endurance, improved aerobic capacity, decreased body fat or weight loss for the population used in this study. However, the slide board would appear to be an effective mode for aerobic conditioning,. The subjects were able to exercise at target heart rates between 70 and 80% of their maximum VO2 for durations of 15-30 minutes. For individuals of above average fitness, ranging in age from 19 to 30 years old, and training for seven weeks on a slide board, significant increases in left leg flexion endurance and maximum heart rate may occur.

The participants in this study did not significantly improve maximum VO2, and many of the leg strength and endurance measurments recorded, however, they were able to maintain pre-test values with completion of the program. Since the subjects were at an above average fitness level, it may have been unrealistic to expect vast improvements in the parameters measured.

Recommendations

Slideboard exercise requires the use of the large muscles in the legs, can provide high level exercise intensities, and can be sustained for at least 15-30 minutes by individuals of good to above average fitness levels. It is recommend that another training study of longer duration and higher intensity be performed with the population used in this study. It is recommended that the same study be conducted with a relatively sedentary group of individuals to see if significant changes will result from the training. It is also recommend that a lateral agility test be included in the pre and post measurements since slideboard exercise requires the use of the hip adductor and hip abductor muscles while pushing laterally from one bumper to the other.

APPENDICES

APPENDIX I

INFORMED CONSENT & PAR Q

UNIVERSITY OF NEVADA, LAS VEGAS
EXERCISE PHYSIOLOGY LABORATORY

INFORMED CONSENT

CONSENT TO PARTICIPATE IN A RESEARCH STUDY
UNIVERSITY OF NEVADA-LAS VEGAS
A SEVEN WEEK TRAINING STUDY ON SLIDEBOARDS

PURPOSE:

Because you are a young, healthy individual you are asked to participate in a research study. We hope to determine the benefits of seven weeks of training on slideboards.

SUBJECTS:

Ten to fifteen apparently healthy male volunteers between the ages of 18 and 30 will be used in this study.

PROCEDURES:

If you decide to volunteer, we will be determining whether seven weeks of training on a slide board three times a week will have a significant effect on aerobic capacity, lower body strength, lower body endurance, body composition and flexibility. You will be required to exercise three times a week for seven weeks. The exercise sessions will last approximately 45 minutes. Pre and post tests include max VO2 tests on the treadmill, isometric strength and endurance tests of knee flexion/extension, hip flexion/extension, hip abduction/adduction, and skinfold measurements.

ALTERNATIVES:

The training protocol will be the same for all subjects.

RISKS:

There are some discomforts and possible dangers involved in the study. The study involves exercising on the slideboard, and although there is always possible dangers of falling or tripping, and that exercise may result in muscle soreness, breathlessness and light headedness, the risks to you are minimal. However, before and after the study a maximum treadmill test is given. This test involves running on the treadmill to your maximum (voluntary maximum) while we collect your expired air which is analyzed for oxygen uptake. This is a strenuous test and muscle soreness, breathlessness, dizziness, and light headedness may occur, however, maximum care, supervision, and preparation will be taken to minimize any hazard or danger.

BENEFITS:

You will contributing to a research project that will provide information on the possible benefits of regular exercise using the slideboard. You will be participating in a structured aerobic exercise program.

CONFIDENTIALITY:

Your name will not be reported in the study. Numbers will be used to represent your data. The information from the study will be submitted to journals for publication.

RIGHT TO REFUSE OR WITHDRAW:

You may refuse to participate and still receive the care you would receive if you were not in the study. You may change your mind about being in the study and quit after the study has started. If the study design or use of the data is to be changed, I will be so informed and my consent reobtained.

QUESTIONS:

If you have any questions, please ask us. If you have additional questions later, Doug Smith will be happy to answer them at the UNLV Exercise Physiology Laboratory. The phone number to call is 895-4102.

You will be given a signed and dated copy of this form to keep

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YOUR SIGNATURE BELOW WILL INDICATE THAT YOU HAVE DECIDED TO VOLUNTEER AS A RESEARCH SUBJECT AND THAT YOU HAVE READ THE INFORMATION PROVIDED ABOVE.

Date ____________ Signature of Participant ____________

Date ____________ Signature of Investigator ____________

PARTICIPANT IDENTIFICATION

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)*
A Self-administered Questionnaire for Adults

PAR Q & YOU

PAR-Q is designed to help you help yourself. Many health benefits are associated with regular exercise, and the completion of PAR-Q is a sensible first step to take if you are planning to increase the amount of physical activity in your life.

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

Common sense is your best guide in answering these few questions. Please read them carefully and check the ☑ YES or NO opposite the question if it applies to you.

YES NO

☐ ☐ 1. Has your doctor ever said you have heart trouble?

☐ ☐ 2. Do you frequently have pains in your heart and chest?

☐ ☐ 3. Do you often feel faint or have spells of severe dizziness?

☐ ☐ 4. Has a doctor ever said your blood pressure was too high?

☐ ☐ 5. Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise?

☐ ☐ 6. Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to?

☐ ☐ 7. Are you over age 65 and not accustomed to vigorous exercise?

If You Answered

YES to one or more questions

If you have not recently done so, consult with your personal physician by telephone or in person BEFORE increasing your physical activity and/or taking a fitness test. Tell him what questions you answered YES on PAR-Q, or show him your copy.

programs

After medical evaluation, seek advice from your physician as to your suitability for:

- unrestricted physical activity, probably on a gradually increasing basis.
- restricted or supervised activity to meet your specific needs, at least on an initial basis. Check in your community for special programs or services.

NO to all questions

If you answered PAR-Q accurately, you have reasonable assurance of your present suitability for:

- A GRADUATED EXERCISE PROGRAM - A gradual increase in proper exercise promotes good fitness development while minimizing or eliminating discomfort.
- AN EXERCISE TEST - Simple tests of fitness (such as the Canadian Home Fitness Test) or more complex types may be undertaken if you so desire.

postpone

If you have a temporary minor illness, such as a common cold.

* Developed by the British Columbia Ministry of Health. Conceptualized and critiqued by the Multidisciplinary Advisory Board on Exercise (MABE).

Reference: PAR-Q Validation Report, British Columbia Ministry of Health, May, 1978.
*Produced by the British Columbia Ministry of Health and the Department of National Health & Welfare. M28-120

APPENDIX II

SCORE SHEETS

UNIVERSITY OF NEVADA, LAS VEGAS
EXERCISE PHYSIOLOGY LABORATORY

VO2 Max Test Protocol

Name:______________________ No:______________

Height:__________ Weight:___________

Date:____________ Pred. Max HR:____

Stage 1: 6mph/0% grade HR________ RPE_______

Stage 2: 6mph/3% grade HR________ RPE_______

Stage 3: 6mph/6% grade HR________ RPE_______

Stage 4: 6mph/9% grade HR________ RPE_______

Stage 5: 6mph/12% grade HR________ RPE_______

Stage 6: 6mph/15% grade HR________ RPE_______

Stage 7: 6mph/18% grade HR________ RPE________

VO2 Max: ______________

Heart Rate:
at VO2 Max_________ at 70% VO2 Max________

at 75% VO2 Max_____ at 80% VO2 Max________

UNIVERSITY OF NEVADA, LAS VEGAS
EXERCISE PHYSIOLOGY LABORATORY

Pre/Post-Test Recording Form

Name:____________________________ No.:________

Age:________ Height:___________ Weight:___________

Date:_____________

Hip Extention:
Pre-Peak Force________________ Endurance_________
Post-Peak Force_______________ Endurance_________

Hip Flexion:
Pre-Peak Force________________ Endurance________
Post-Peak Force_______________ Endurance_______

Leg Extention:
Pre-Peak Force________________ Endurance________
Post-Peak Force_______________ Endurance_______

Leg Flexion:
Pre-Peak Force________________ Endurance________
Post-Peak Force_______________ Endurance_______

Abduction:
Pre-Peak Force________________ Endurance________
Post-Peak Force_______________ Endurance_______

Adduction:
Pre-Peak Force________________ Endurance_________
Post-Peak Force_______________ Endurance________

UNIVERSITY OF NEVADA, LAS VEGAS
EXERCISE PHYSIOLOGY LABORATORY

Pre / Post-Test Body Composition

Tricep Skinfold:
Pre-test__________mm
Post-test__________mm

Abdomen Skinfold:
Pre-test__________mm
Post-test__________mm

Iliac Skinfold:
Pre-test__________mm
Post-test__________mm

Thigh Skinfold:
Pre-test__________mm
Post-test__________mm

APPENDIX III

PERCENT BODY FAT EQUATION

Jackson & Pollock Sum of Four Skinfold Equation for Males

Percent Fat: Men

Sum of Four Sites:
1. Abdomen
2. Ilium
3. Tricep
4. Thigh

Percent fat = .29288 (sum of 4) - .0005 (sum of four squared) + .15845 (AGE) - 5.76377

REFERENCES

Astrand, P. (1986). Textbook of work physiology: Physiological bases of exercise. (3rd ed.). New York: Magraw-Hill.

Bergfeld, J.A., & Anderson, T.E. (1984). Achieving mobility, strength, and function of the injured knee. In L.Y. Hunter & F.J. Funk (Ed.). *Rehabilitation of the Injured Athlete.* St. Louis: C.V. Mosby.

Blair, S.N. et al. (1992). Physical fitness and all-cause mortality: A prospective study of healthy men and women. *Journal of the American Medical Association, 262,* (17), 2395-2401.

Brooks, G.A., & Fahey, T.D. (1984). Exercise physiology: Human bioenergetics and its applications. (1st ed.) New York: John Wiley & Sons.

Cox, M.L., Bennett, J.B., & Dudley, G.A. (1986). Exercise training-induced alterations of cardiac morphology. *Journal of Applied Physiology, 61*(3), 926-931.

Daub, W.B., Green, H.J., Houston, M.E., Thomson, J.A., Fraser, I.G., & Ranney, D.A. (1983). Specificity of physiologic adaptations resulting from ice-hockey training. *Medicine and Science in Sports and Exercise, 15*(4), 290-294.

De Boer, R.W. et al. (1987). Specific characteristics of speed skating: implications for summer training. *Medicine and Science in Sports and Exercise, 19*(5), 504-510.

Duchateau, J., & Hainaut, K. (1984). Isometric or dynamic training: Differential effects on mechanical properties of a human muscle. *Journal of Applied Physiology, 56* (2), 296-301.

Garber, C.E., McKinney, J.S., & Carleton, R.A. (1992). Is aerobic dance an effective alternative to walk-jog exercise training. *Journal of Sports Medicine and Physical Fitness, 32,* 136-141.

Golding, L.A., Myers, C.R., & Sinning, W.E. (Eds.). (1989). Y's way to physical fitness (3rd ed.). Champaign: Human Kinetics.

Greer, N., Blatherwick, J., Serfass, R., & Picconatto, W. (1992). The effects of a hockey-specific training program on performance of bantam players. *Canadian Journal of Sports and Science, 17* (1), 65-69.

Harrelson, G.L. (1991). Use of the slide board following anterior cruciate ligament reconstruction. *Sports Medicine Update,* Winter 1991.

Holden, S., MacRAE, H., Dennis, S.C., Bosch, A.N., & Noakes, T.D. (1992). Effects of training on lactate production and removal during progressive exercise in humans. *Journal of Applied Physiology*, 72 (5), 1649-1656.

Hole, J.W. (1990). Human anatomy and physiology. (5th ed.). Dubuque, IA: Wm. C. Brown.

Hutchinson, W.W., Maas, G.M., & Murdoch, A.J. (1979). Effect of dry land training on aerobic capacity of college hockey players. *Journal of Sports Medicine, 19*, 271-276.

Intruction Manual. (1991). Axis Muscle Tester. FARO Medical Technologies Inc.

Jackson, A. S., and Pollock, M. L. (1978). Generalized equations for predicting body density for men. *British Journal of Nutrition, 40*, 497-504.

Krause, S., & Golding, L. A. (1992). The energy cost of sliding on the Kneedspeed slideboard. *Sports Medicine, Training and Rehabilitation, 4*, 139-157. (From *Southwest Chapter of the American College of Sports Medicne Abstracts*, 1992, pg. 150)

Lamb, D.R. (1979). Physiology of exercise: Responses and adaptations. New York: Macmillan.

Leiber, D.C., Leiber, R.L., & Adams, W.C. (1989). Effects of run-training and swim-training at similar absolute intensities on treadmill VO2max. *Medicine and Science in Sports and Exercise, 21*(6), 665-661.

Mannion, A. F., Jakeman, P. M., & Willan, P. L. T. (1992). Effects of isokinetic training of the knee extensors on isometric strength and peak power output during cycling. *European Journal of Applied Physiology, 65*, 370-375.

Osbourne, R. (1990). Slide-em cowboy: The new lateral movement trainer. *American Fitness Quarterly, 9*,(4),10-13.

Ott, R. L. (1993). An introduction to statistical methods and data analysis. (4th ed.) Belmont, Ca: Duxbury Press.

Paffenbarger, R. S. Jr., Hyde, R. T., Wing, A. L., Hsieh, C. C. (1986). Phsyical Activity, all-cause mortality, and longevity of college alumni. *New England Journal of Medicine, 314*, (10), 605-613.

Pate, R.R., et al (Eds.). (1991). Guidelines for exercise testing and prescription. (3rd ed.). Philadelphia: Lea & Febiger.

Perkins, R. (1990). Euroglide. *High Tech coaching and training*, (6), 20.

Poehlman, E.T., & Danforth, E. (1991). Endurance training increases metabolic rate and norepinephrine appearance rate in older individuals. *American Journal of Physiology, 261*, 233-239.

Powers, S.K., & Howley, E.T. (1991). Exercise Physiology: Theory and application to fitness and performance. (2nd ed.). Madison: Brown & Benchmark.

Reese, S., & Lavery, K. (1991). Slide boards: A conditioning and rehabilitative tool. *National Strength and Conditioning Association Journal, 13*(5), 22-24.

Snyder, A.C., O'Hagan, K.P., Clifford, P.S., Hoffman, M.D., & Foster,C. (1993). Exercise responses to in-line skating: Comparisons to running and cycling. *International Journal Sports Medicine, 14*, 38-42.