THE UNIVERSITY OF ALBERTA

# EFFECTIVENESS OF DIFFERENT RESISTANCE TRAINING METHODS ON SELECTED PHYSIOLOGICAL MEASURES

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled EFFECTIVENESS OF DIFFERENT RESISTANCE TRAINING METHODS ON SELECTED PHYSIOLOGICAL MEASURES submitted by PAUL S. CHAHAL in partial fulfilment of the requirements for the degree of MSc.

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## ABSTRACT

The purpose of the study was to investigate the effects of isotonic concentric and eccentric, isokinetic concentric and eccentric, and a combination of these lower limbs training methods on: resting blood pressure, resting heart rate, back and abdominal strength, heart rate at peak force during various strength tests, vertical jump, body weight, lean body mass, and percentage of body fat.

Forty healthy volunteer male subjects ranging in age from 18-28 years participated in this study. The subjects were randomly assigned to one of the following groups: Isotonic (n = 11), Isokinetic (n = 9), Isotonic-Isokinetic (n = 9), and the Control group (n = 11). All training groups performed four sets of exercise per session, for 15 minutes, three times a week, for 10 weeks. Four tests were conducted: Test 1 (Pre-test), Test 2, Test 3, and Test 4 (Post-test), each being at three and a half weeks interval.

For all maximum back and abdominal strength variables the strength scores were significantly higher at Test 3 and 4 in relation to Test 1 and 2. The maximum isometric back strength heart rate was signifcantly higher at Test 1 in comparison to the subsequent tests. The maximum isotonic concentric leg-lift heart rate was higher at Test 1 in relation to Test 4. The resting systolic blood pressure at Test 2 was higher than at Test 1 and 4. The resting diastolic and the mean blood pressure were higher at Test 2 in comparison to the other test sets. The vertical jump was

also significantly higher at Test 4 in relation to Test 1.

The group main effect was significant for the maximum isometric back strength. The Isotonic-Isokinetic group had significantly greater strength in comparison to the Control group.

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# Chapter I

## STATEMENT OF THE PROBLEM

### Introduction

Strength, power and endurance are important and necessary components of physical fitness for successful participation in any sporting activity. Physical fitness is of interest to the athletic population as well as the general public for betterment of physical performance, cosmetic, and health related reasons.

In order to acquire these important components, some type of muscle resistance training is necessary. Muscular resistance training is a well known and popular training method for increasing muscular strength and endurance, as well as power. A general review of the literature in the area of resistance training reveals that different types of resistance training programs can cause improvement in these physical fitness parameters (Hettinger, 1961; Hakkinen et al., 1981).

Besides the increase in muscular strength, endurance and power, the research evidence indicates that resistance training can also cause improvement in other physical fitness related parameters. There is evidence to suggest that resistance training can cause a decrease in the resting blood pressure (Stone et al., 1983; Siconolfi et al., 1985; Fry, 1986). Thus far, this issue is controversial and has yet to be throughly investigated.

The improvement in physical performance and related parameters caused by resistance training seems to be dependent on type of exercise program, and type of muscular contraction i.e. isotonic-concentric, isotonic-eccentric, isokinetic-concentric, isokinetic-eccentric, isometric or some combination of these, and the speed of contraction.

Sit-ups and back-lift types of exercises are commonly performed to improve abdominal and back muscular strength (Ashton, 1973; Cailliet, 1981). Generally, many experts accept that in resistance training of lower limbs, the force acting through the spine, would improve back and abdominal muscular strength. Both of these muscle groups act to stabilize the upper body. The function of the abdominal muscles during squat type of exercise appears to be to increase the intra-abdominal pressure which in turn relieves the load off the vertebral column (Bartlink, 1957; Morris et al., 1961, Cailliet, 1981). The weight held over the shoulders in isotonic type of exercise (free weights) has to act through the spine. Because of this it was hypothesized that lower limb training, especially the isotonic type, would improve the strength of both of these muscle groups. However, to date no research evidence could be found to support or refute this hypothesis.

Resistance training has also been known to bring about changes in body fat and lean body mass. There is some research evidence to suggest that it may increase lean body mass and decrease percentage of body fat (Pipes and Wilmore, 1975; Stone et al., 1983; Hurley et al., 1984). The decrease in body fat appears to be related to the percentage of maximum voluntary contraction (MVC), duration, and speed of contraction. A combination of increased percentage of MVC, long duration, and high contractile speed appears to be the best components of resistance training programs that contribute to the greatest drop in body fat (Pipes and Wilmore, 1975; Stone et al., 1983). The percentage body fat does not seem to decrease significantly following exercise programs with low percentage of MVC force, low contractile speed, and duration (Pipes and Wilmore, 1975; Hurley et al., 1984).

The effect of high resistance training on heart rate during rest and at peak maximum voluntary force has also not been throughly investigated. There is some evidence that the resting heart rate does decrease somewhat. The stimulus to decrease the resting heart rate (RHR) appears to be a training program of moderate to high intensity (DeMaria, 1978; Kanakis and Hickson, 1980; Stone et al., 1983).

**Purpose of the Proposed Study**

Various studies have reported the effects of resistance training on body composition, RHR, exercise heart rate, back strength, resting blood pressure, and vertical jump. However, all of these variables have not been throughly studied for different loads, type of contractions, and velocities to determine the changes exclusively due to resistance training. The main purpose of the study was to investigate which exercise program was most effective in causing the desirable changes in the dependent variables of the study.

The specific purposes of the study were:

1. To assess the effects of isotonic concentric and eccentric, isokinetic concentric and eccentric and a combination of these training methods on resting blood pressure.
2. To investigate the effect of high resistance training on the resting heart rate.
3. To determine if high resistance training of the lower extremities improves the isometric strength of abdominal and back musculature.
4. To investigate how the heart rate changes at the peak force during various strength tests and to determine any changes caused by the high resistance training programs.
5. To determine which training method is superior for improving vertical jump.
6. To determine which training method is most effective in increasing lean body mass and decreasing percentage of body fat.

**Hypotheses**

The following hypotheses were tested at $\alpha = 0.05$ level:

1. After and during 30 training sessions spread over 10 weeks, there will be no significant difference among the

exercise groups for each of the following dependent variables under study:

a. resting systolic blood pressure, diastolic blood pressure, mean blood pressure,

b. resting heart rate,

c. heart rate at peak force during various strength tests,

d. vertical jump,

e. body weight, percentage body fat and lean body mass.

2. At termination of the training program the Isotonic, and Isotonic-Isokinetic groups will show significant increases in abdominal and back muscular strength in comparison to Isokinetic and Control groups.

3. At the end of the study the control group will not show any significant change in any of the dependent variables under study.

**Limitations of the Study**

The limitations of the study were:

1. Extraneous variables such as height, weight, somatotypes and external activities of the subjects (i.e. all the physical activities or work performed by the subjects apart from those of the study), could not be controlled.

2. Volunteer subjects were requested to participate in this research study.

3. During hydrostatic weighing, the residual lung volume was estimated as 30% of the vital capacity.

4. Attrition: due to personal reasons, some subjects dropped out of the study. This affected the number of subjects in each group that finally completed the training study.
5. Accuracy of the measuring instruments.
6. Human source of error.

## Delimitations of the Study

The delimitations of this study were:

1. Forty healthy male subjects between age range of 18-28 years who were inexperienced in resistance training of the lower limbs.
2. Duration of the study was 11 weeks: 10 weeks for training and one for testing.
3. Training was done three times a week; each training session being about 48 hours apart.
4. Independent and dependent variables:
   a. Independent Variables
      1) Training workloads in kilograms and cable speed of 13 cm per second.

   b. Dependent Variables
      1) Resting systolic blood pressure, diastolic blood pressure, and mean blood pressure.
      2) Resting heart rate.
      3) Maximum Isometric back strength at hip angle of 160°.
      4) Maximum Isometric abdominal strength at hip

angle of 160°.

5) Heart rate at peak force during various strength testing.

6) Standing vertical jump.

7) Body weight, percentage of body fat, and lean body mass.

## Operational Definition of Terms

1. Isometric Strength: is defined as the maximum effective force or tension a group of muscles can exert in a single maximal voluntary contraction at a given angle.
2. Isotonic-eccentric Exercise: An activity in which the muscle contracts and lengthens, resulting in the development of tension and visible movement (Knuttgen and Kraemer, 1987).
3. Isotonic-concentric Exercise: An activity in which the muscle contracts and shortens, resulting in the development of tension and visible movement (Knuttgen and Kraemer, 1987).
4. Isokinetic-eccentric Exercise: An activity which allows a contracting muscle to develop tension or force while being compelled to lengthen by an external agency that is moving at a fixed mechanically controlled speed (Knuttgen and Kraemer, 1987).
5. Isokinetic-concentric Exercise: An activity which allows a contracting muscle to develop tension or force at a

mechanically controlled speed (Knuttgen and Kraemer, 1987).

6. Isometric (Static) Exercise: An activity in which the muscles contract without visible shortening in length, but tension is continuously generated (Knuttgen and Kraemer, 1987)

7. Repetition Maximum (RM): This is the load or maximum weight that can be lifted rhythmically a specified number of times but not more (e.g., 6 RM means the maximum weight that can be lifted only six times continuously and not more without a rest period).

8. Set: One series of repetition without an intervening rest period.

9. Repetition(s): The number of times a dynamic or static contraction is repeated in a given exercise set.

10. Percent Body Fat: Percent body fat is that percentage of body weight that is actually adipose tissue, estimated from Brozek's formula (Brozek et al., 1963).

11. Lean Body Mass: The body weight minus the weight of the body fat (Fox and Mathews, 1981).

## Chapter II

## REVIEW OF THE LITERATURE

### A. DETERMINANTS OF THE HEART PERFORMANCE

#### Heart Rate

Both the sympathetic and parasympathetic nervous system act to control the heart rate (HR). Blood carried catecholamines will also influence the HR. The sympathetic cardiac accelerator nerves secrete norepinephrine (noradrenaline) and some epinephrine (adrenaline) at their endings on the heart to make it beat faster. The parasympathetic vagus nerve endings secrete acetylcholine, which slows the rhythm of the heart beat (Lamb, 1984; Fry, 1986).

Endurance and high intensive strength training type of exercise appears to reduce the resting heart rate. Kanakis and Hickson (1980) conducted a study to investigate the effect of strength training of the lower-limbs on the resting heart rate. They had nine healthy male subjects, 18-27 years of age, who exercised five days per week. Three days per week the subjects performed five sets of five RM of squats, and three sets of five RM of leg flexions and leg extensions. On the two alternative days they performed three sets of five RM of leg presses, and three sets of 20 RM of calf raises. There were three minutes rest between each set. The duration of the study was 10 weeks. At the termination of the exercise program the resting heart rate decreased significantly from 65 ± 2 and 58 ± 1.7 beats/min ($p < 0.001$). The decrease in the resting heart rate may have been due to increase in the ventricular end-diastolic dimension or possibly by increase in the activity ratio of parasympathetic over the sympathetic nervous system on the heart.

Shvartz (1966) conducted a study to investigate the effect of isotonic and isometric exercises on the heart rate using a military press in a sitting position. Twelve subjects with mean age of 21 years participated in this study. The isometric exercises were performed for 45 s with one-half, two-thirds, and maximum resistance. The results indicated that increasing the load resulted in a proportional increase in HR. Increasing the load to maximum resulted in a near twofold increase in the HR. The mean resting HR was 71.8 beats per minute (bpm). The mean HR after performing with maximum load was 136.6 bpm (Shvartz, 1966). Kino et al. (1975) conducted a study in which they investigated the HR response of 10 young individuals to an isometric exercise. The age range of subjects was 23 to 31 years. The subjects were asked to do a maximum voluntary isometric contraction on a handgrip dynamometer and sustain it for at least 30 s. The mean increase in HR was 51.6 ± 5.7 bpm. The increase in HR during isometric hand grip exercise was thought to be mainly caused by rapid withdrawal of vagal influences on the heart and partly by adrenergic influences of central origin and reflexes in the muscle spindle mechanoreceptors. Goldstraw and Warren (1985) indicated that the increase in HR during isometric exercise occurs in two distinct phases. "There is an initial rapid increase due to withdrawal of cardiac parasympathetic activity, followed by a further increase probably due to cardiac sympathetic stimulation" (Goldstraw and Warren, 1985, p. 56).

In their study, Stone et al. (1983) investigated the effect of high resistance weight training on the resting heart rate (RHR) of healthy college age males. The experimental group (n = 9) was trained similarly to Olympic weight-lifters for eight weeks. Heart rate was measured at the radial artery. At the termination of the training program there was a small but nonsignificant tendency for reduction in RHR. As Stone et al. suggested, the reduction in RHR produced by weight training may reflect an increase in the parasympathetic/sympathetic input ratio. As well, they suggested that heart rate reduction as a result of weight training is likely to be accompanied by an increased stroke volume due to a longer diastole or increased left ventricle end-diastolic internal dimension.

## Blood Pressure

Another important measurement concerning the entire circulatory system is that of <u>blood pressure</u> (BP). This is determined by multiplying cardiac output by peripheral vascular resistance. For all practical purposes, however, BP is measured with a sphygmomanometer (Kirkendall et al., 1980; Fry, 1986).

The type of muscle fiber or muscle involved in contraction seems to be related to systemic systolic and diastolic BP responses. The BP appears to increase to a greater extent via a fast-twitch type of muscle in comparison to a slow-twitch. The rise in BP has been suggested to be due to build up of metabolites within the muscle. The potassium ion has been proposed as possibly the prime metabolite responsible for an increase in BP (Petrofsky et al., 1981).

Most epidemiologic studies have shown an inverse relationship between resting blood pressure (RBP) and usual levels of physical fitness or activity (Gibbons et al., 1983; Cooper et al., 1985; Siconolfi et al., 1985). "Prospective studies of the effects of increased regular exercise on resting BP have generally shown that elevated BP returns toward more normal values after physical training" (Siconolfi et al., 1985, p. 452). Cooper et al. (1976), reported data from 3,000 self-selected male patients who visited the Cooper clinic in Dallas, Texas. The authors of the study showed that men with lower fitness levels (fair, poor, and very poor) had significantly higher average blood pressure (137/87 mm Hg) than those in the excellent fitness category (122/80). Gibbons et al. (1983) examined Cooper clinc data for 3,900 women and found systolic and diastolic blood pressure to be significantly correlated to fitness level, r = 0.27 and r = 0.20 respectively.

The effect of high intensity resistance training on resting blood pressure has not been throughly investigated. All of the related research literature reviewed indicates that RBP does not increase with high resistance weight training (Stone et al., 1983; Colliander and Tesch, 1985; Fry, 1986). Colliander and Tesch (1985) found that resistance training does not elevate RBP. In their study they made comparisons between age matched body builders (n = 24) and the medical students (n = 35). Mean SBP of both groups was not significantly different (123 ± 10 mm Hg for body builders and 126 ± 12 mm Hg for the medical students).

There is some research evidence to indicates that high resistance weight training may reduce the RBP (Stone et al., 1983; Siconolfi et al., 1985; Fry, 1986). Brousseau et al. (1981) studied the RBP changes in rats performing different types of exercise programs. There were 24 normotensive rats assigned to either isometric training (hanging over water), sham (held over water), or a control group. The duration of the study was of eight weeks. Mean RBP measured prior to sacrifice showed the isometric training group (126 ± 3 mm Hg) to be significantly different from the other groups (sham 137 ± 5, and control 140 ± 6 mm Hg). The pre-training BP values were not reported in the study.

Stone et al. (1983) investigated the effect of high resistance training on the RBP. In this study an experimental group of nine healthy college age males was trained similarly to Olympic weight lifters for eight weeks. All had been sedentary at least two months prior to the initiation of the experiment. Previous experience with any form of weight training was minimal. There were two major reasons given for using this training protocol: 1) the method of preparation has been experimentally and empirically shown to be superior to other methods of preparatory strength power training and 2) it is widely used. At termination of the training program SBP had decreased significantly from 119.3 ± 13.4 to 114.8 ± 9.0 mm Hg. Diastolic BP did not change significantly. It is important to note that the exercise program utilized in this study was of very high intensity. The duration of the exercise sessions was greater than 45 minutes per day, six days per week.

**Blood Pressure and Heart Rate**

Greer et al. (1984) studied HR and BP response to several methods of strength training. Heart rate, and BP were determined on five subjects performing five different strength training exercises at 75 and 100% of MVC (maximum voluntary contraction). The exercises included isometric, isokinetic, and isotonic with free weights. The subjects were five female volunteers between 33 and 48 years of age ($\bar{x}$ = 39.4 years) with no known cardiovascular disease or musculoskeletal disorders. The Cybex II isokinetic exercise equipment was utilized in conducting the isometric and isokinetic contractions. Systolic blood pressure and DBP increased significantly with all exercises, and HR increased with most exercises. In some, but not all, of the exercise sessions in which two measurement were made at different times, HR and BP were reported to be higher for the second measurement. If the contraction is greater than 15% of MVC, BP and HR have been shown to rise steadily throughout the time the muscle contraction is maintained. Furthermore, the contraction of a number of muscles at the same time has been indicated not to be additive, rather the HR and BP elevations are proportional to the percentage of MVC used by the most vigorously contracting muscle (Greer et al., 198?).

It seems that the "central command" is not neccesssary in order to obtain an increase in HR and BP in response to isometric exercise in man. Hultman and Sjoholm (1982) reported that the receptors within the muscle have the full capacity to adjust central circulation to the muscle work performed. The predominating mechanism that governs the circulatory adjustments in the muscle has remained unsettled. Whether it is a "central command" orginating from brain or a feed-back loop controlled by receptors within the working muscles is not certain. The role of central command has been stressed by Goodwin et al. (1972); whereas, Petrofsky et al. (1982), suggested predominance of a muscle factor.

## B. BODY COMPOSITION, AND PHYSICAL PERFORMANCE

### Body Fat and Lean Body Mass.

The effect of strength training on body fat and lean body mass seems to be variable according to the intensity of the training program. Strength training programs of moderate to high resistance, long duration, and high speed of contraction appears to result in greater decreases in the percentage of body fat (Pipes and Wilmore, 1975; Stone et al., 1983). The percentage of body fat does not appear to decrease significantly following exercise programs of low resistance, low contractile speed, and of short duration (Pipes and Wilmore, 1975; Hurley et al., 1984).

Hurley et al. (1984) investigated the effect of high-intensity strength training on percentage of body fat and lean body mass. There were 13 subjects in the training group and 10 in the control. Their age ranged from 40-60 years. They trained on variable resistance Nautilus apparatus. During each workout the training group performed one set of each of 14 exercises in the following order: hip and back, leg extension, leg press, leg curl, arm cross, decline press, pullover, torso-arm pulldown, lateral raise, over head press, behind neck, behind neck pulldown, omni triceps, and omni biceps. The subjects performed between eight and 12 RM for all exercises during each training session. Body density was determined by the hydrostatic method. Residual lung volume was determined by oxygen dilution technique immediately after underwater weighing while the subject was still in the water. Percent body fat was estimated from body density values using Brozek et al.'s (1963) formula. The duration of the study was 16 weeks. At the termination of the exercise program the percentage of body fat did not change significantly. Lean body mass did increase significantly from 66.9 ± 2.6 to 68 ± 2.7 kg ($p <$ 0.05). It appears that the duration of the training sessions was not long enough to cause a significant decrease in the percentage of body fat.

Harris and Holly (1980) in their study investigated the effect of circuit weight training, in border-line hypertensive subjects, on lean body mass and other measures of body composition (which other measures of body composition were not reported in the study). There were 10 borderline hypertensive (140/90 to 160/95 mm Hg) subjects in the experimental group and 16 in the control. The training program consisted of 10 stations (2 arm, 4 trunk, and 4 leg) in three sets of 20-25 repetitions with an exercise/rest ratio of 3:1 (45 s exercise to 15 s rest). The experimental group trained three times a week for nine weeks. Body composition measures were determined by underwater weighing and skinfold measurements. At the termination of the training program lean body mass increased significanly from 64.1 to 65.4 kg ($p < 0.0001$). Other measures of body composition did not show any significant change. A possible explanation for not obtaining any significant changes in other measures, in this study, may be due to the short duration of the training program and small sample size.

Stone et al. (1983) investigated the effects of eight weeks of high intensity Olympic style weight training on body fat and lean body mass. Body density was determined by hydrostatic methods. Percentage of body fat was estimated from the equation developed by Brozek et al. (1963). Residual volume was estimated for each subject by: vital capacity x 0.24 (Wilmore, 1969). At the termination of the exercise program the lean body mass had increased significantly from 64.9 ± 7.4 to 67.3 ± 7.7 kg. The greatest gains occurred during the first five weeks of training. Body fat had decreased significantly from 18.9 ± 6.3 to 15.9 ± 6.1 percent. As suggested by the authors of the study the positive changes in body composition, especially increases in lean body mass, are strongly related to skeletal muscle strength and power gains.

Pipes and Wilmore (1975) conducted a comparison study of different training methods to determine their effect on body fat and lean body mass. There were 36 male volunteer subjects in age range of 20-38 years who were randomly assigned to one of the four groups: isotonic, isokinetic low speed contraction, isokinetic high speed contraction, and a control. Training was conducted three days per week, 40 minutes per exercise session for eight weeks. Body density, lean body mass and fat were assessed at the beginning and end of the training period by hydrostatic weighing. The oxygen dilution technique was utilized to assess residual lung volumes. The percentage of body fat was estimated from the equation developed by Siri (1956).

At the termination of the exercise programs body composition changes occurred within all training groups. Total body weight increased for all training groups, while lean body mass increased significantly only in isotonic (from 66.3 ± 7.5 to 67.8 ± 7.0 kg) and isokinetic high speed (from 71.1 ± 7.2 to 73.9 ± 7.8 kg) groups. All training groups exhibited significant decreases in absolute percentage of body fat, with the isokinetic high speed group (from 11.6 ± 0.5 to 9.4 ± 0.6%) decreasing the relative body fat significantly more than isokinetic low speed (from 15.6 ± 0.7 to 15.1 ± 0.7%) or isotonic (from 11.9 ± 0.7 to 10.2 ± 0.7%) groups. There were no significant changes in any of the measured parameters for the control group.

**Vertical Jump**

The improvement of motor performance tasks such as vertical jump, 40 yard dash, broad jump, and softball throw appears to be most related to the speed of contraction. Training done at maximum or near maximum speed may or may not be sufficient to cause improvement in vertical jump or other similar power demanding events. Some muscular training appears to be necessary for improvement to take place.

Pipes and Wilmore (1975) investigated the effect of isotonic and varying speeds of isokinetic exercises on standing long jump, 40 yard dash, softball throw for distance, vertical jump and two-handed sitting shotput. Thirty-six male volunteers, ranging in age from 20-38 years were randomly assigned to one of four groups: isotonic, isokinetic low speed contraction, isokinetic high speed contraction, and control. Each of the exercise groups performed the bench press, biceps curl, leg press, and bent rowing. The training was conducted three times per week, with an average duration of 40 minutes per day. The duration of the study was of eight weeks. Subjects in the isotonic group initially trained at 75% of their 1 RM for approximately eight repetitions, for each of three sets. The subjects were encouraged to do the greatest number of repetitions possible in each of the three sets. Resistance was increased for each lift when individuals were able to do more than 10 repetitions on their last set. Isokinetic groups trained at maximum resistance at varying speeds of limb movement. The isokinetic low speed group trained at 24° of limb movement per second, for eight repetitions per set. Isokinetic high speed group trained at 136° of limb movement per second, for 15 repetitions per set. At termination of the training programs neither the isotonic nor control groups had significant changes for any of the measures of motor performance tasks. The isokinetic low speed group demonstrated significant improvement in 40 yard dash, softball throw and vertical jump (from 20.1 ± 3.7 to 21.2 ± 2.8 inches). The isokinetic high speed group exhibited significant improvement in 40 yard dash, softball throw, two-handed shotput, and vertical jump (from 21.6 ± 1.8 to 22.5 ± 1.9 inches). Based on the results of the study, the authors concluded that isokinetic training procedures are superior to isotonic training when positive changes in motor performance are desired. The authors suggested that isokinetic training procedures may, by design, allow the contracting muscle or muscle group to generate more muscular force while an individual is performing the specific motor task.

Smith and Melton (1981), in their study, investigated the effect of isokinetic and isotonic-variable resistance exercise on motor performance. There were 12 subjects who participated in the study. The subjects were volunteer adolescent males between the ages of 16 and 18 years with none of them participating in training for any specific athletic team or performance. They were randomly assigned to one of the four groups: control, isotonic variable-resistance training (Nautilus), low-speed isokinetic (5, 10, and 15 rpm), and high-speed isokinetic training (30, 40, and 50 rpm). The training program for the variable-resistance group consisted of a Nautilus program where the individuals initially exercised at 80% of their maximum effort for 10 repetitions for three sets. All groups trained three times per week. When the subjects were tested for motor performance the high-speed isokinetic group dominated over the others. For high speed there was a gain of 5.38% in vertical jump versus 3.87% for the slow isokinetic, 1.57% for the isotonic variable resistance, and -8.92% for the control; 9.14% gain in standing broadjump versus 0.42, 0.28, and -0.19%; and 10.11% gain in the 40 yard dash vs. 1.12, 1.35, and 1.9%. In conclusion, the importance of concept of specific training was stressed. If an individual trains in a modality similar to the one in which he will be tested, the results would be better than someone training in modes different from the testing. This study shows that isokinetic exercises at high speeds produce much better results when the results tested are in the high speed contraction velocities (e.g. vertical jump and 40 yard dash).

Wathen and Shutes (1982) conducted a comparison study to investigate the effects of eight week long, selected isotonic and isokinetic exercise modality programs on 40 yard dash and standing broad jump. Three groups of eight athletes were randomly selected from a group of 100 varisity football players. Each individual was pre-tested for a one repetition maximum effort in the barbell parallel squats. The isotonic group did variable-resistance type of training on apparatus recommended by Nautilus. The individuals initially exercised at 80% of their maximum effort for 10 repetitions in three sets. The low speed isokinetic group exercised on a Cybex II isokinetic dynamometer at 5, 10, and 15 repetitions per minute (rpm) until 50% fatigue was on the graph.

The high-speed isokinetic group also trained on the Cybex II. These subjects trained at limb movement rates of 30, 40, and 50 rpm. The subjects were also trained until 50% of fatigue was recorded on the graph. The results demonstrated no significant increase for 40 yard dash and standing broad jump. In this study, no significant improvement in the performance variables may possibly be due to that the athletes participating were probably already trained. Therefore they could not improve very much thereafter. As indicated by the authors of the study, isokinetic exercises at high speeds produce much better results when the tests are in high-speed contraction velocities (e.g., 40 yard dash and standing broad jump). In this study fast isokinetic exercise was shown to improve performance levels in tests of quick acceleration more efficiently than low-speed isokinetic training or training with isotonic variable resistance modes.

There is no distinct evidence to support which type of exercise method is superior for improving the motor performance tasks. Most studies support the isokinetic high speed training method as probably the best method for improving the vertical jump or other motor performance tasks in comparison to isotonic or low speed isokinetic training (Pipes and Wilmore, 1975; Smith and Melton, 1981; Wathen and Shutes, 1982). Some authors have shown that isotonic type of training can cause improvement in motor performance tasks (Chui, 1950; Schultz, 1967). Thus, it appears that, depending on resistance, speed, duration, and type of contraction, either training method may improve the height of vertical jump. There still seems to be a great need to investigate the effect of variable training programs in terms of exercise resistance, speed of contraction, duration of the training session, and length of the training program for diffrent training modes on motor performance tasks.

## C. VERTEBRAL COLUMN

**Bending and Lifting.**

During trunk flexion up to about 45°, as measured from the vertical, the upper body load is mainly supported by activity of trunk extensor muscles. As flexion approaches 45° the tension in vertebral and paravertebral ligaments increases and in extensor muscles decreases (Cailliet, 1981). Further flexion occurs as a rotation of the pelvis by relaxation of the posterior leg and hip muscles (this occurs when the legs are kept straight as shown in Figure 1).

During lifting the pelvis first rotates with ligaments of the spine bearing the brunt of the stress until 45° of flexion is reached, at which point the extensor muscles of the back become active (Figure 1). This is one of the reasons for keeping the back straight and knees bent when lifting. If the back is not kept straight, the load would be mostly supported by the paravertebral ligaments, possibly causing ligamentous sprain in the lower back. In this

Figure 1 has been removed because of the unavailability of copyright permission.

Information: Muscle-ligamentous control in lifting.

Source: Cailliet, 1981.

position, the spine flexion of 45° or greater, there would be a higher magnitude of stress on the ligaments, also due to decreased leverage of the ligaments in comparison to the muscles and possibly increased distance of weight being supported from the center of gravity of the body.

The relationship between the distance of a weight from the center of gravity of the body and the force exerted by extensors of the spine is shown in Figure 2. The resultant force acting in the vertical direction is the sum of the weight and the force exerted by the extensor muscles of the spine.

As indicated by Cailliet (1981), to lift and bend properly and safely one must have:

1. good flexibility of the lower back and the lower extermities,
2. good abdominal muscle tone,
3. good strength of back extensor muscles and leg muscles (Forssell, 1980; Cailliet, 1981), and
4. proper knowledge of the body mechanics which requires:
   a. training and practice,
   b. the action automatic,
   c. no distraction to impede the proper execution, which can result from fatigue, anxiety, haste, depression, and anger.

Figure 2 has been removed because of the unavailability of copyright permission.

Information: The relationship of the distance of a carried weight from the center of gravity and the resultant tension.

Source: Cailliet, 1981.

**Role of the Abdominal Muscles in Lifting**

In lifting heavy objects from the floor, the abdominal muscles exert their effect by increasing the intra-abdominal pressure, thus relieving part of the load off the spine, and possibly by decreasing the lumbar lordosis and the angle between the vertebral segments (Bartelink, 1957; Morris et al., 1961; Cailliet, 1981). The intrathoracic pressure created by the muscles of respiration, such as the internal intercostals, external intercostals, diaphragm and the abdominal muscles, also acts in conjunction with intra-abdominal pressure to relieve the load off the spine. Morris et al. (1961, p. 346) indicated that:

> The spinal column is attached to the sides of and within two chambers, the abdominal and thoracic cavities; the action of the trunk muscles converts these chambers into nearly rigid-walled cylinders containing (1) air and (2) liquid and semi-solid material. Both of these cylinders are capable of transmitting part of the forces generated in loading the trunk and thereby of relieving the load off the spine itself.

As demonstrated in the study by Morris et al. (1961), when lifting weight the increase in pressure occurs in the following sequence (as shown in Figure 3):

1. there is little increase of pressure or muscle activity as the subject bends forward,
2. the pressures rise rapidly as the subject begins to

strain to lift the weight, and

3. the maximum peak of pressure occurs at the moment the inertia of the weight is overcome and the weight is lifted from the floor.

Figure 4. shows similiar findings for static contractions at various hip angles as measured from the vertical. With the subject in the upright position and the weight held at arm's length, the pressures again drop toward resting levels. The trunk muscles also become active simultaneously with the elevation of pressure during the lift.

The intrathoracic pressure, although much less than the intra-abdominal, is more sustained and fluctuates less during the lift (Figure 3 and 4).

The rationale for having strong abdominal musculature is to provide protection for lumbar disc from exercise loads through the development of intra-abdominal pressure. This concept is based on the work related to the ability of intra-abdominal and intrathoracic pressure to relieve the load off the spine. Jackson and Brown (1983) indicate that evidence fails to demonstrate that abdominal strength is directly correlated with the ability to increase intra-abdominal pressure. Morris et al. (1961) stated that the activity required of the abdominal oblique muscles in developing intra-abdominal pressure during loading of the spine is only one-sixth of that obtained with maximum voluntary contraction. Further research is needed in this

Figure 3 has been removed because of the unavailability of copyright permission.

Information: Dynamic loading of the spine.

Source: Morris et al., 1961.

Figure 4 has been removed because of the unavailability of copyright permission.

Information: Static loading of the spine.

Source: Morris et al., 1961.

area to determine the ability to develop intra-abdominal pressure with training.

Abdominal pressure can be increased artifically to unload the lumbar spine. This has been shown by measuring intradiscal pressure with and without an inflated corset with an abdominal pad (Cailliet, 1981). From empirical observations it seems that abdominal pressure may be induced by using a weight belt while lifting. There is one possible disadvantage of artificially induced pressure; that is the abdominal musculature may become too dependent on the external support (Cailliet, 1981). It may weaken them further rather than causing a possible training effect to improve the strength of this musculature. The consequence might be an increased probability of sustaining a back injury.

It has been suggested that force provided by the abdominal muscles may provide up to 30-40% of the force necessary for support. This force may increase to even greater levels during the lifting of heavy weights or objects, especially when an individual executes a Valsalva manoeuver (Alexander, 1985).

## Trunk muscle strength.

A study concerning trunk muscle strength during constant velocity movements was conducted by Thorstensson and Nilsson (1982). The effects of gravity were removed by performing the movements in the horizontal (lying on a side) and varied with velocity and position. The typical recordings obtained in the study are shown in Figures 5.

As shown in Figure 5, the strength of abdominal musculature was demonstrated to be less than half that of the back extensors through most of the range of motion. The abdominal muscles have been shown to be more susceptible to fatigue than the back extensors (Hasue et al., 1980, Smidt et al., 1983).

The development of abdominal strength seems to be essential in order to provide a balance in strength between the abdominal and back musculature and possibly to relieve the load off the spine during lifting for safety purposes.

Figure 5 has been removed because of the unavailability of copyright permission.

Information: Typical recordings of maximal torque produced during flexion and extension of the trunk.

Source: Thorstesson and Nilson, 1983.

# Chapter III

## METHODS AND PROCEDURE

### A. SUBJECTS

To recruit subjects, an advertisement was placed in the University of Alberta's newspaper, The Gateway, as well as the Edmonton Journal and Edmonton Sun. All respondents were required to fill out a "Physical Activity Readiness Questionnaire" (PAR-Q; Appendix 1). The Par-Q was used as a basis for subject selection in addition to the age range criteria of 18 to 28 years. Sixty healthy volunteer male subjects out of 61 respondents were selected to participate in the study. Due to a large dropout rate for various personal reasons, only 40 subjects completed the study. The mean height, weight, and age for the subjects who completed the study, for each group, are listed in Table 1. The subjects were inexperienced in resistance training and did not have contraindications to participate in a strength conditioning program.

Each subject was required to sign the informed consent form (Appendix 2) after having been informed of the benefits and possible risks associated with participating in a training study of this nature. The subjects were asked not to engage in any strength conditioning activities outside the training regimes of the study.

In order to motivate the subjects in the control group to abstain from any resistance training and dropping out of

Table . Physical Characteristics of the Subjects.

| | Ht cms | Wt kgs | Age Year |
|---|---|---|---|
| Group 1 | 1.76 ± .06 | 77.6 ± 13.7 | 22.5 ± 3.4 |
| Group 2 | 1.79 ± .06 | 76.5 ± 5 | 21.3 ± 3.1 |
| Group 3 | 1.75 ± .09 | 75.4 ± 13.3 | 23.8 ± 4.0 |
| Group 4 | 1.75 ± .06 | 75 ± 8.6 | 22.4 ± 3.2 |

Mean ± SD

the study, an incentive was promised. The incentive was to offer a similar training program of the subjects' choice as the training groups at the end of the study.

B. ASSIGNMENT OF SUBJECTS TO GROUPS

A table of random numbers was utilized to assign the subjects to the exercise and control groups. Fifteen subjects were assigned per group. The purpose of random assignment to the groups was to ensure that there was no systematic bias in the composition of the groups and also to control the effects of extraneous variables on the internal validity of the results of the study.

C. FAMILIARIZATION EXERCISE SESSIONS

Physical fitness tests involve elements of skill which must be mastered by the subjects before the tests are administered (Vertex, 1985). Two familiarization exercise sessions were conducted by all subjects before the Test 1. For each session the subjects performed two sub-maximal contractions at about 60-70% of maximum voluntary effort. For vertical jump, per familiarization session, each subject practiced three jumps similar to as was done during the testing. The purpose of the familiarization sessions was to acquaint the subjects with the skills associated with the tests.

## D. DESCRIPTION OF TESTING PROTOCOLS AND INSTRUMENTATION

### Vertical Jump

Vertical jump height was measured in centimeters using a "Jump Board". The board has marked height intervals in both inches and centimeters.

Firstly, the subject's standing reach was recorded. The subject stood parallel to the wall with dominant arm closest to it. He then reached as high as he could with the dominant arm, keeping his toes and heels on the floor . During the reach both feet were kept close to the wall to maximize the height reached. The subject touched the board at maximum extension of the arm, with the middle finger of the dominant hand. Before each reach and jump the subject applied white chalk on his finger tips. The chalk marks on the board were used to determine the maximum height of the reach and the jump. The reach was recorded from the floor. The reaching procedures were repeated once after the initial attempt. The highest value of the two attempts was recorded.

After the reach was recorded, the subject stood with the heels of both feet chest width apart in order to jump. Width of chest for each subject was measured with an "Anthropometric Measuring Stick" before jumping. The subject was asked to take a ready position, knees and elbows slightly bent. He stood with the center of his feet 44 cm from the wall. From the ready position he then swung his arms two times as if getting ready to jump. On the third arm swing the subject jumped as high as he could. At the peak of the jump the subject touched the board with his finger tips at maximum height possible. The jump was repeated two more times after the initial attempt. There was at least a 30 to 45 s rest between each jump. The highest value of three jumps was recorded. The jump height was obtained by subtracting the reach height from the total jump height as measured from the floor.

Resting Blood Pressure

The resting blood pressure for each subject was measured on the left arm after he sat in a chair for at least 10 minutes. Siconolfi et al. (1985), in their study, took two consective right arm RBP readings on the subjects, in a seated position with at least five minutes between measurements, and five minutes rest in sitting. In Bonnanno and Lies study (1974) at least three readings, separated by more than five minutes were taken, while the subjects were seated. The RBP was taken as the average of the three lowest readings (Bonnanno and Lies, 1974).

At least ten minutes of rest, in this study, was given before measurement of the blood pressure. The blood pressure was not recorded if the subject had been doing some form of strenous physical activity prior to this test. Three readings of systolic and diastolic pressures were taken, each being five minutes apart. The average of the last two auscultating BP readings was used. The first reading was not used because for most subjects it had a tendency to be slightly higher than the subsequent readings.

The blood pressure was estimated indirectly by means of a sphygmomanometer. "This instrument consists of an inextensible cuff containing an inflatable bag" (Berne and Levy, 1981, p. 106). The cuff was wrapped around the left upper arm so that inflatable bag would lie between the cuff and the skin, directly over the brachial artery. The lower margin of the cuff was placed about two and a half centimeters above the antecubital space (Kirkendall et al., 1980). The artery was occluded by inflating the bag, by means of a rubber squeeze-bulb, to a pressure in excess of arterial systolic pressure. The pressure in the bag was measured by means of a mercury manometer. Pressure was released from the bag at a rate of two or three mm Hg per heartbeat by means of a needle valve in the inflating bulb. A stethoscope was applied to the skin on the antecubital space over the brachial artery to measure the systolic and diastolic pressures. While the pressure in the bag exceeds the systolic pressure, the brachial artery was occluded and no sound was heard. When the inflation pressure fell just below the systolic level, the small spurt of blood escaped through the cuff and a slight tapping sound (called Korotkoff sound) was heard, indicating the systolic blood pressure reading. As inflation pressure continue to fall more blood escaped under the cuff per beat and Korotkoff sounds were heard as louder "thuds". As the inflation pressure approached the diastolic level, the Korotkoff sounds tended to muffle. As the pressure in the cuff fell below the diastolic level the sounds tended to disappear (fifth phase). This indicated the diastolic pressure (Berne and Levy, 1981).

The same cuff was used to measure the BP of all subjects. The width of the cuff was 14 cm which is the proper size for someone with arm girth of 35 cm. Thus, the true BP reading may have been slightly underestimated for the subjects with smaller arm girths and overestimated for the ones with larger arm girths (Kirkendall et al., 1980). The forearm position on average was about 10 cm lower than the fourth intercostal space at the sternum. In using this arm position the mean BP would be about eight mm Hg lower then that recorded using the technique recommended by the American Heart Association (Kirkendall et al., 1980) which positions the forearm at the level of the fourth intercostal space at the sternum.

Isometric Back-Lift Strength Test.

Each subject executed a maximal isometric back-lift at a hip angle of 160° (Ashton, 1973). The hip angle was measured with a goniometer before testing during the submaximal warm-up contraction (Figure 6). While performing the test the subject was required to keep his back straight. For safety reasons, this was standard for all subjects to eliminate any excessive curving of the upper back while

Figure 6. Maximum Isometric Back Strength Test at Hip Angle of 160°.

lifting. Excessive curving of the back tends to put most of the brunt of the load on the paravertebral ligaments. A straight back tends to increase the precision of testing by eliminating any variation in the hip angle while the test is being performed. The position of the feet was also standardized with the outside edges of both feet being shoulder width apart. Shoulder width for each subject was measured before the testing with an "Anthropometric Measuring Stick". A white paper tape was put on the standing surface with markings on it to facilitate placement of the feet in the appropriate position.

Before testing each subject was asked to do a warm up contraction at about 60 to 70% of their maximum voluntary effort. After the warm up contraction the subject did two maximal contractions. Each contraction was five seconds in duration. There was four minutes rest between each lift (or a contraction). The force of the lift was transmitted via a load cell to the Honeywell Biomedical System Model 1912. The load cell was connected between the cable and the bar (Figure 6). The lift with a maximum force generated was used for the purposes of this study.

## Isometric Abdominal Strength Test

Each subject executed a maximal abdominal strength test at a hip angle of 160° while standing. The hip angle was measured with a goniometer before the testing during a warm up contraction. The warm up contraction was performed at 60 to 70% of subject's maximum voluntary effort. To measure the abdominal strength the cable was connected to a shoulder harness via two pulleys located on posterior aspect of the back board (Figure 9). The shoulder harness was specially designed to facilitate the measurement of abdominal strength. Because it was fitted with adjustable straps it could be adjusted to fit subjects of various sizes (Figure 7-9). For testing the placement of the harness hook on the subjects' upper back was standardized to be in a position parallel with the inferior border of the upper arms at arm-pit level (Figure 8B). The upper pulley was adjusted so it would be at a height parallel to the hook, with the subject in the standing position. The load cell was connected between the back two pulleys (Figure 9B). A piece of chain was used in the back to adjust the cable length according to the variable hook height for different subjects.

The back and feet positions were standardized the same as for the Isometric Back-lift Strength Test. Procedures for warm-up, two maximal contractions, and rest between them, were similar for this test as for the back-lift test. The contraction with maximum force generated was used for the purposes of the study.

### Hydrostatic Weighing.

A rectangular tank six feet in height, four feet in width and 10 feet in length was used for hydrostatic

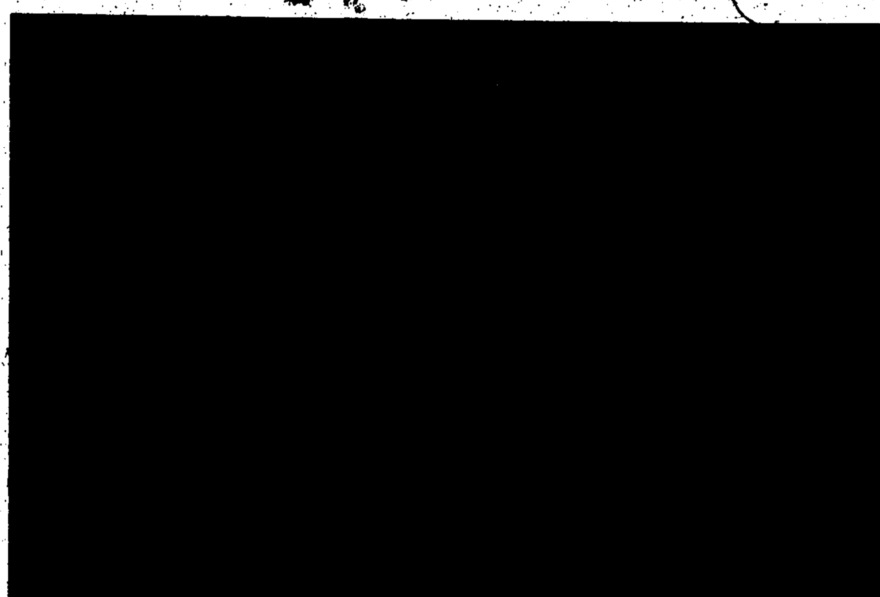



Figure 7. Shoulder Harness Belt for Abdominal Strength Testing.

(A)

(B)

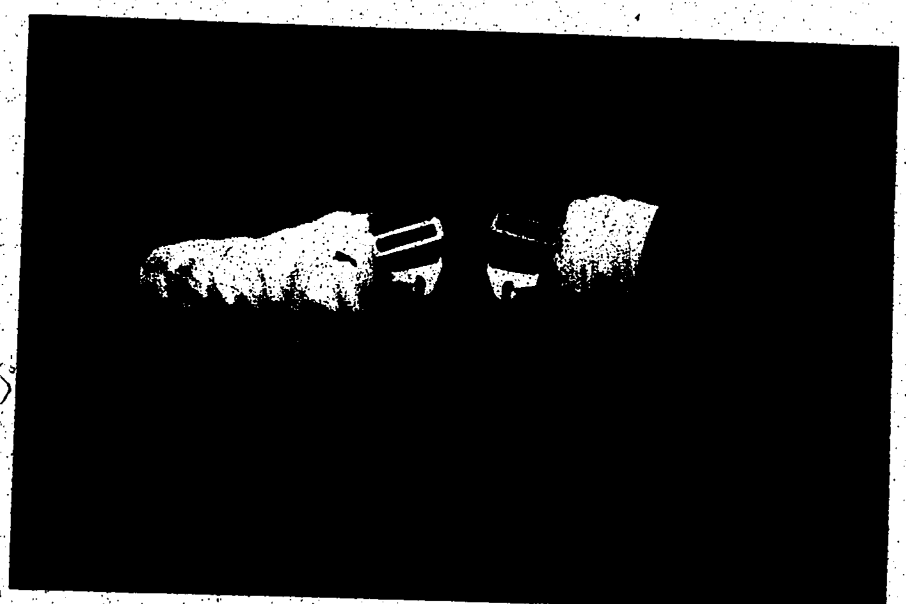


Figure 8. (A) Anterior View of the Shoulder Harness as it Fits the Subject, (B) Posterior View.

(A) (B)

Figure 9. Maximum Isometric Abdominal Strength Testing
(A) Anterior View: Testing Position and Measurement of Hip Angle,
(B) Posterior View: The Framework of Testing Equipment and Testing Position of the Subject.

weighing. Within the tank an aluminum chair was suspended from a load cell which was connected to a Sargent recorder (model SR). Prior to each test, the recorder was calibrated and water temperature was measured and recorded. Before entering the tank, the subject dressed in a swim suit and was weighed on a balance scale to the nearest tenth of [illegible] kg. Upon entering the tank the subject sat in the [illegible] and a 9.45 kg diver's weight belt was placed across the thighs close to the waist. Vital capacity was measured using a six litre vitalometer with the subject seated in the water to neck level. The largest volume of three trials was assumed to be the best estimate of the vital capacity (Moyer; 1971).

The technique for hydrostatic weighing was as follow:

1. Air bubbles were dislodged from the hair and the body.
2. The subject maximally inhaled and closed the nasal passages.
3. The subject leaned forward from the waist until the body was completely submerged in the water.

This procedure was repeated until two similar chart readings were obtained. The recording that indicated the greatest inhalation was used as the hydrostatic weight (Moyer; 1971).

Residual volume was estimated as 30% of the vital capacity (Macnab and Quinney; 1984). Percent body fat was calculated according to the formula of Brozek et al. (1963).

**Heart Rate**

Heart rate was recorded on a Honeywell Biomedical System Model 1912. The chest electrodes were applied to monitor the HR. The electrodes were situated bilaterally just below the nipples in the fifth inter-costal space, and a reference electrode on the left shoulder (Figure 6, and 10). Heart rate was calculated from the length in mm occupied by a three beat complex on the E.C.G. recording paper (Sedgwick, 1965).

The resting heart rate was recorded immediately after the blood pressure measurements while the subject was still seated in the chair.

**Heart Rate Monitoring During the Maximum Isotonic-Concentric Leg Lift Strength Test**

To perform this test, the subject stood underneath the bar with his feet 12 to 15 inches apart. He then flexed his knees to an angle of 90° (half squat position) and lifted the weight-loaded bar by extending his knees fully.

After the first lift, if the subject was able to do another repetition with the same load, he was asked to stop. The load was then increased by 5 or 10 kg depending on the capability of the subject being tested. The entire procedure was repeated until a subject's one repetition maximum (1 RM) was established. Rest periods between trials were four minutes in duration. The energy pathway (ATP-PC) involved in this type of activity can be 100% restored within three to

Figure 10. Heart Rate Monitoring During Maximum Isotonic-Concentric Leg Lift Strength Test.

five minutes (Fox and Mathew, 1981). Empirical observation of most individuals indicate that they are usually ready to perform the next subsequent lift between two to three minutes after the prior attempt. Therefore a rest interval of four minutes between trials was consider more than adequate.

Determination of a subject's 1 RM during the pretest took some time and effort on the part of the subject and testing team, as many trials were required before the true 1 RM was determined. For subsequent test, his previous performance was used as a guideline before attempting 1 RM and, thus, did not require same amount of time and effort. Before commencement of the test the subjects were requested to warm-up by performing one or two sets of 8-10 repetitions with a submaximum load. Different subjects had variable ways of approaching their maximum lifts. Some subjects did one to three sets of warm-up before attempting the maximum lift. Others preferred and did no warm-up sets before attempting the lift.

Heart rate was printed out on the "recording paper" by the Honeywell Biomedical System Model 1912 throughout the testing periods.

**Heart Rate Monitoring During the Maximum Isokinetic Concentric and Eccentric Leg Lift Strength Test**

The electric trunk and leg dynamometer was utilized for this test (Singh, 1972). The dynamometer was calibrated before the start of every testing session. At the start of the test, the subject stood on the dynamometer, feet shoulder width apart (Figure 11). The cable length was adjusted according to subject's height and knee angle. The cable was adjusted so that it was tight at full extension. For safety purposes, each subject was asked to keep his knees slightly bent even at full extension. The cable was then attached to the webbed belt which was fastened securely to his waist. The subject held on to the bar for greater sense of stability.

The speed of the cable was pre set to 13 cm per second. For the eccentric phase of the test the subject was required to resist the pull from a standing position while the cable was being pulled down. For the concentric phase of the test the subject pulled up forcefully from the half squat position (90° knee flexion) until full extension was attained while the cable was being released. Heart rate and the tension developed in the lower extremity muscles were recorded by the Honeywell Biomedical System Model 1912.

**Isotonic Concentric and Eccentric Strength Apparatus**

This apparatus was specially designed and built to eliminate the eccentric contraction phase which is a feature in isotonic strength training or measurement. This equipment was designed so that it could automatically return the weight to the starting position within a specified time independent of any effort from the subject. If the subject

(A) (B)

Figure 11. Heart Rate Monitoring During the Maximum Isokinetic Concentric and Eccentric Leg Lift Strength Tests; (A) Standing Position, (B) 90° Position During the Testing.

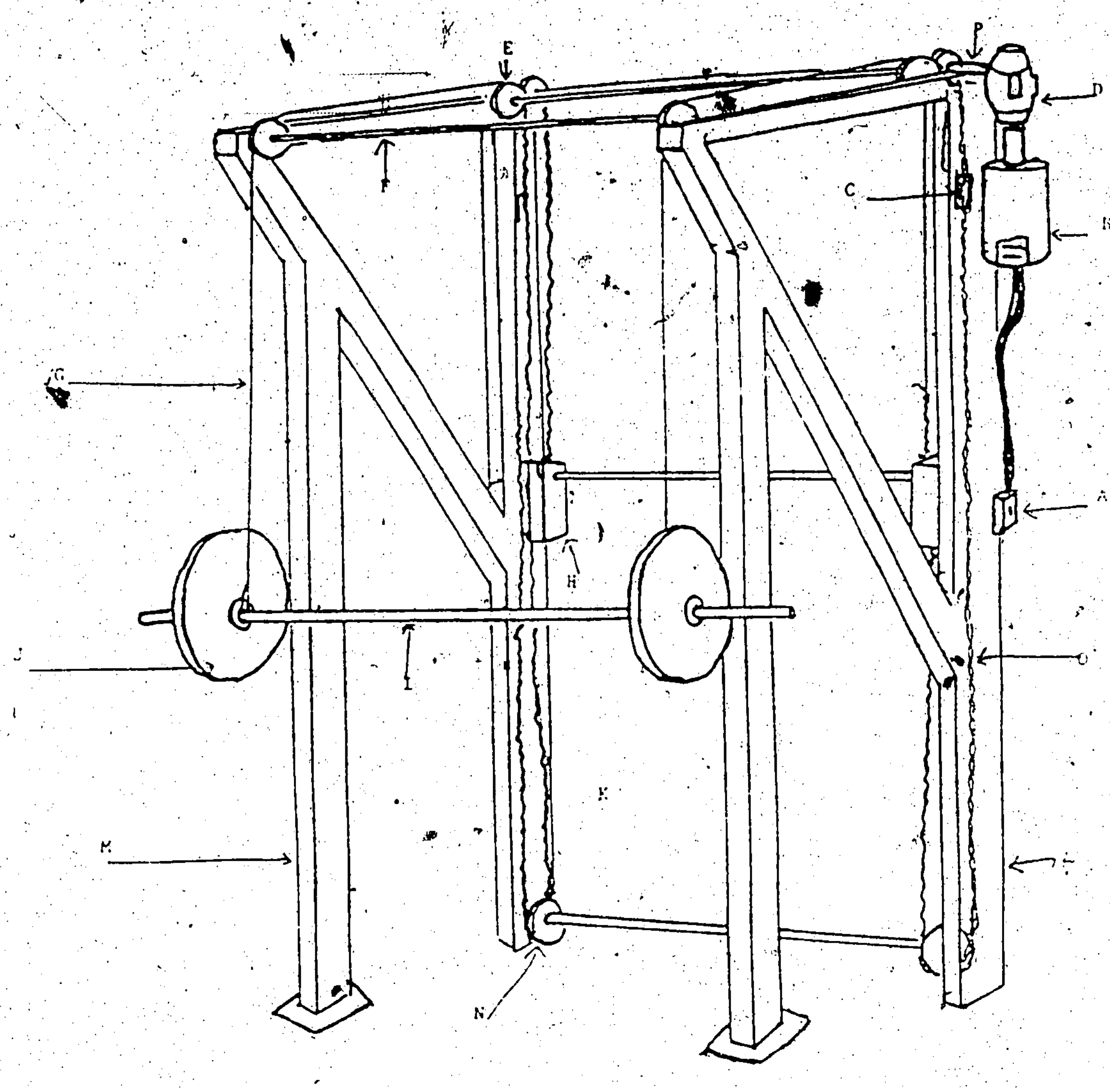



Figure 12. Isotonic Training and Testing Apparatus.

KEY

A. On & Off Switch
B. 1/3 HP Electric Motor
C. Range Setting Switch
D. 90° Angle Drive
E. Pulley
F. 1" diameter Steel Shaft
G. Aircraft cable
H. Counter Weight
I. Weight Bar
J. Flat Weight
K. Supporting Wall
L. 2" Sq. 16 gauge Steel Tubing
M. Stabilizing Support
N. Sprocket
O. 3/8 pitch chain
P. One-way Clutch

had to do more than one repetition, as soon as the weight loaded bar came back to the starting position, he lifted it again using his legs while keeping his shoulders underneath it. This cycle continued until the required number of repetitions were achieved.

The apparatus consisted of an electric motor and a gear box which was fixed onto the upright supports. On top of the upright supports, there was a 2.5 cm diameter steel bar to which chains, 5 mm thick and 2.5 m long, were attached. The weight, according to subjects' need, was loaded onto the bar. Two suspending counter weights were attached to the bar located in the back of this apparatus (Figure 12).

On lifting the loaded bar, after a certain height (approximately two to three cm) the rising bar triggered the micro-switch fixed on the upright supports. The activation of the micro-switch enabled the loaded bar to be lowered automatically to the predetermined starting position as soon as the subject completed the lift. If the subject could not complete the lift, the weight would not drop. Instead, it returned to the starting position as soon as he stepped out from underneath the loaded bar. This built-in safety mechanism ensured that no one was injured while training or during testing with this apparatus.

**Electric Trunk and Leg Dynamometer**

The electric trunk and leg dynamometer (Singh, 1972), can measure isokinetic concentric and eccentric leg strength as well as isometric back and abdominal strength while standing. The dynamometer consisted of an electric motor connected to a double-acting hydraulic cylinder from which a 3000 lb capacity cable passed over the two ball bearing - pulleys and emerged at a point between the subject's feet and in front of him (for strength testing and training of the lower limb). The dynamometer as it is can be used to measure back-lifting strength while standing.

For leg-training the cable was connected to special belt (Figure 13). This belt was further connected to a steel bar firmly attached to a four-inch webbed belt. Sewn to the webbed belt was an automobile seat belt with a buckle. By adjusting the buckle, the belt can be securely fastened around the subject's waist.

For strength testing of the abdominal musculature the cable was connected to two pulleys located on posterior aspect of the back board. The cable then connected to the shoulder harness through the back board (Figure 9).

A load cell which acted a strain gauge was connected to the Honeywill Biomedical System Model 1912 which prints out the torque being exerted by the contracting muscles.

## E. TESTS

Four test sets, Test 1, Test 2, Test 3, and Test 4 were conducted throughout the course of the study. For each test set, all the dependent variables took two days of testing time. On the last testing day, for each test set, upon

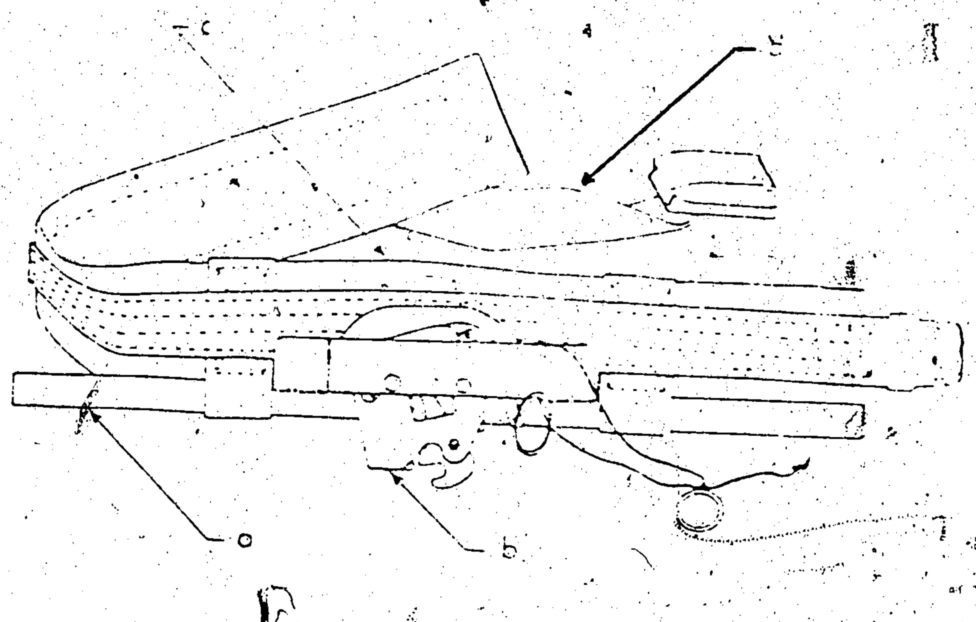



Figure 13.

Special belt; (a) Steel bar, (b) Release mechanism, (c) Webbed belt, (d) Automobile seat belt (Singh, 1972).

completion of the tests the subjects were allowed to resume their training usually on the same day. For each group, training and testing protocol is summarized in Table 2.

**Test 1**

Two days after the end of the familiarization training sessions, a Test 1 was conducted over a period of two days. A delay in testing following the familiarization sessions was necessary in order to allow the subjects to recover fully before the testing. The tests were conducted in the following order (random ordering for test 3-6, day one; and test 1, day two):

Day one:

1. Measurement of resting Blood Pressure,
2. Resting Heart Rate,
3. Vertical Jump,
4. Maximum Isometric Back-lift Strength,
5. Maximum Isometric Abdominal Strength,
6. Monitoring of Heart Rate during Maximum Isokinetic concentric, eccentric leg, and Maximum Isometric Back and Abdominal strength testing.

Day two:

1. Heart Rate monitoring during Maximum Isotonic concentric strength testing, and
2. Hydrostatic Weighing.

For each test set (Test 1 to Test 4), for all the groups, the order of strength and performance testing, test

Table 2. Training and Testing Protocol of the Study.

| | Test 1 | 10 TS | Test 2 | 10 TS | Test 3 | 10 TS | Test 4 |
|---|---|---|---|---|---|---|---|
| Isotonic | x | x | x | x | x | x | x |
| Isokinetic | x | x | x | x | x | x | x |
| Isotonic-Isokinetic | x | x | x | x | x | x | x |
| Control | x | | x | | x | | x |

3-6 (day one), and test 1 (day two) was randomized. In addition, since test 6 (day one) and test 1 (day two) both required maximum voluntary contractions of the lower limbs they were always performed on the alternative days. Randomization was done to hold constant any learning or conditioning effect that may occur or other factors that could have cumulative effect on the outcome (Chaffin et al. 1980).

**Test 2**

After the 10 training sessions Test 2 was conducted to determine the rate and magnitude of the increase in training adaptations.

**Test 3**

At the end of 20 training sessions Test 3 was conducted. It followed a similar pattern as the previous tests.

**Test 4**

At the end of 30 training sessions which were spread over 10 weeks, a Test 4 was conducted in order to determine the overall effects of the experimental treatments. To allow for proper recovery of the subjects, this test was conducted two days following the cessation of the training program.

## F. RELIABILITY

In order to determine the internal consistency or stability of the test measures, a reliability coefficient (test-retest) was computed, for all tests, before commencement of the training programs (Lyman, 1977; Borg and Gall, 1983). Two days after the Test 1 fifteen subjects were randomly selected from those taking part in the study to participate in a retest measure. For each test a correlation coefficient was then computed between the subjects two sets of scores. Inter-rater reliabilty was also computed for maximum isometric back and abdominal strength, and all the heart rate variables. For inter-rater reliability two independent observers estimated the scores from the data print outs obtained during the testing.

## G. TRAINING REGIME OF THE EXERCISE GROUPS

The subjects trained three times a week for a total of 10 weeks. The groups of muscles trained were those of the lower extremity of the body. Each repetition of exercise was three seconds for all the training groups except for the isotonic-eccentric contraction which was 4.5 s per repetition. The training contraction time for all the exercise groups was 72 s per training session.

### Isotonic-Concentric and Eccentric Training

The subjects in this group trained with a specially constructed free weight apparatus (Figure 12, 14, 15). It was electrically controlled and had been designed to eliminate the eccentric phase of the training program.

For concentric contraction, the subject trained with a workload of 80 to 90% of 1 RM, two sets of six repetitions (Johnson et al., 1976). The rest interval between sets was three minutes. To start the training contraction the subject assumed a half squat position (90° knee flexion) and then lifted the weight loaded bar with the shoulders using his legs by extending the knees fully (Figure 14). After full extension he again assumed half squat position, while the loaded bar returned to the starting position without any effort from the subject. The subject then repeated the lift. This process continued until the required number of repetitions was completed. Each repetition was three seconds in duration.

For eccentric training contraction, with the loaded bar of 120-130% of 1 RM on the shoulders, the subject lowered the weight by slowly flexing the knees to half squat position from the full extension thereby generating tension in the lower extremity muscles (Johnson et al., 1976). At the end of the contraction, the trainers on hand lifted the loaded bar back to the starting position (Figure 15). This enabled the subject to start again. The subject did two sets of four repetitions. Each repetition was 4.5 s and the rest interval between sets was three minutes.

Maximal strength (1 RM) of the subjects was determined at the beginning of each week in order to adjust the training workload.

### Isokinetic Concentric and Eccentric Training

For this group the procedure for training was the same as in the test except that the load cell was disconnected from the cable. The speed of the moving cable was set to 13 cm per second which means that one repetiton on the average took about 3 s to extend from 90° knee flexion to 180° extension. Since the speed of the cable was mechanically fixed, the subject could not accelerate the cable more than the set speed, no matter the force applied. The subject did two sets of six repetitions. For warm-up, each subject did six submaximal repetitions before the commencement of the training regime.

For Isokinetic-eccentric training contraction the subject resisted maximally from full extension toward 90° knee flexion while the cable was being pulled downward at a fixed velocity of 13 cm per second. The regime for this training mode was two sets of six repetitions per training session. The rest interval between sets was three minutes.

### Isotonic Concentric and Eccentric with Isokinetic Concentric and Eccentric Training

The subjects in this group did a combination of all the training contractions of the other groups. The training regime for this exercise program consisted of the following:

1. Isotonic-concentric: one set of six repetitions,

Figure 14. Isotonic Concentric Training.

Figure 15. Isotonic Eccentric Training: The Trainee Lifting the Weight Loaded Bar to the Starting Position.

workload at 80-90% of 1 RM.

2. Isotonic-eccentric: one set of four repetitions, workload at 120-130% of 1 RM.
3. Isokinetic-concentric: one set of six repetitions, workload at 13 cm per second.
4. Isokinetic-eccentric: one set of six repetitions, workload at 13 cm per second.

The training contraction occurred over the range of 90° knee flexion to 180° full extension or vice versa. Rest intervals between sets was three minutes.

## H. EXPERIMENTAL DESIGN AND ANALYSIS

The design of the study was 4 (groups) x 4 (tests) experimental control group design with repeated measures on the last factor (tests). Factor one was the Groups with four levels; Isotonic, Isokinetic, Isotonic-Isokinetic and Control group. Factor two was the tests with four levels namely; Test 1, Test 2, Test 3, Test 4.

1. For reliability, the Pearson Product Moment correlation was computed from the Test 1 and retest scores of the 15 randomly selected subjects. The inter-rater reliability, on two set of scores obtained form the same read outs (n = 15) by two independent observers, was also commputed for the abdominal and back strength, and heart rate variables.
2. Data was analyzed using a two-way ANOVA with repeated measures on the last factor. Where there was significant

"F" ratio or statistical interaction (Groups x Tests interaction) Scheffe post hoc test was utilized to determine where the difference was. The Pearson Product Moment correlation was applied to determine the relationship between all the variables under study.

3. Values were considered significant at the $\alpha = 0.05$ level for all the test procedures.
4. The Unique Analysis of Variance was utilized to carry out the statistical analyses (Milken and Johnson, 1984).

## Chapter IV

## RESULTS AND DISSCUSSION

### Reliability

The reliability coefficient was computed on all the dependent variables of the study (Table 3). The inter-rater reliability was computed on all the strength and the heart rate variables (Table 3).

### Maximum Isometric Back Strength

The results were quite similar when absolute back strength, back strength per kg of body weight and lean body mass were determined. For all three variables the test main effect was significant, the scores on Test 3 and 4 were higher in comparison to Test 1 and 2 (Table 4, 5, 8, 9, 11, and 12). For absolute strength and strength per kg of body weight the scores for Test 4 were also significantly higher than at Test 3 (Table 5 and 9).

For maximum absolute back strength the group main effect was also significant, the Isotonic-Isokinetic group being significantly higher than the Control group (Table 4 and 6). The differences between the two groups seems to be due to the subjects in Isotonic-Isokinetic group, on average, being about 10 kg heavier and stronger than those in the Control group. Some strength differences may have resulted due to training for the Isotonic-Isokinetic group and no training for the Control group.

Table 3. Test-Retest Reliability Data for the Dependent Variables of the Study, and Inter-rater Reliability Data for Selected Dependent Variables.

| Dependent Variable | Test-Retest Reliability Coefficient | Interobservable Reliability Coefficient |
|---|---|---|
| Resting Systolic Blood Pressure | 0.81 | |
| Resting Diastolic Blood Pressure | 0.59 | |
| Resting Mean Blood Pressure | 0.71 | |
| Resting Heart Rate | 0.59 | 0.9997 |
| Max. Isom. Back Strength | 0.85 | 0.9963 |
| Max. Isom. Back Strength per Kg of Body Weight | 0.88 | |
| Max. Isom. Back Strength per Kg. of Lean Body Mass | 0.84 | |
| Max. Isom. Abdominal Strength | 0.84 | 0.9799 |
| Max. Isom. Abdominal Strength per Kg of Body Weight | 0.84 | |
| Max. Isom. Abdominal Strength per Kg of Lean Body Mass | 0.71 | |
| Max. Isom. Back St. Heart Rate | 0.52 | 0.9999 |
| Max. Isom. Abdominal St. Heart Rate | 0.21 | 0.9999 |
| Max. Isotonic Con. Leg Lift Strength Heart Rate | 0.35 | 0.9970 |
| Max. Isokinetic Con. Leg Lift Strength Heart Rate | 0.70 | 0.9993 |
| Max. Isokinetic Ecc. Leg Lift Strength Heart Rate | 0.41 | 0.9972 |
| Vertical Jump | 0.73 | |
| Body Weight | 0.998 | |
| Percentage of Body Fat | 0.88 | |
| Lean Body Mass | 0.997 | |

$r \geq .52$: significant at $\alpha = 0.05$ level

Table 4. Summary Table of F-ratios for Maximum Absolute Isometric Back Strength.

| Source | SS | MS | df | F-ratio |
| --- | --- | --- | --- | --- |
| Groups | 24476.28 | 8158.76 | 3.0 | 3.33* |
| Error | 88115.30 | 2447.65 | 36.0 | |
| Tests | 78547.50 | 26182.50 | 3.0 | 120.59* |
| Error | 23448.86 | 217.12 | 108.0 | |
| Groups x Tests | 3217.89 | 357.54 | 9.0 | 1.65 |
| Error | 23448.86 | 217.22 | 108.0 | |

* Denotes Significance at $P < 0.05$

Table 5. Test Main Effect Summary Table for Maximum Absolute Isometric Back Strength.

| Test Set | Mean (kg) | Significantly Different from Test ($\alpha = 0.05$) |
| --- | --- | --- |
| Test 1 | 150.3 | 3, 4 |
| Test 2 | 149.7 | 3, 4 |
| Test 3 | 189.3 | 1, 2 |
| Test 4 | 198.3 | 1, 2 |

Table 6. Group Main Effect Summary Table for Maximum Absolute Isometric Back Strength.

| Groups | Mean (kg) | Significantly Different from Test ( $\alpha$ = 0.05): |
|---|---|---|
| Group I | 179.78 | - |
| Group II | 172.58 | - |
| Group III | 184.69 | 4 |
| Group IV | 152.93 | 3 |

Table 7. Descriptive Statistics Summary Table for Maximum Absolute Isometric Back Strength (kg).

| Group | Test | $\bar{X}$ | SD | Min. | Max. | Significantly Different from Test ( $\alpha$ = 0.05): |
|---|---|---|---|---|---|---|
| I (n=11) | Test 1 | 154.46 | 18.55 | 128.65 | 199.20 | 3, 4 |
| | Test 2 | 158.15 | 19.19 | 124.50 | 192.56 | 3, 4 |
| | Test 3 | [illegible] | 30.64 | 164.34 | 258.13 | 1, 2 |
| | Test [illegible] | [illegible] | [illegible] | 180.11 | 246.51 | 1, 2 |
| II (n=9) | Test 1 | [illegible] | [illegible] | 132.80 | 169.32 | 3, 4 |
| | Test 2 | 151.61 | 17.42 | 121.18 | 172.64 | 3, 4 |
| | Test 3 | 188.78 | 21.27 | 158.52 | 226.59 | 1, 2 |
| | Test 4 | 199.34 | 25.54 | 169.08 | 239.04 | 1, 2 |
| III (n=9) | Test 1 | 156.87 | 28.53 | 120.35 | 196.71 | 3, 4 |
| | Test 2 | 157.39 | 28.93 | 120.87 | 201.69 | 3, 4 |
| | Test 3 | 207.87 | 42.66 | 141.10 | 262.28 | 1, 2. |
| | Test 4 | 216.64 | 38.00 | 156.87 | 268.92 | |
| IV (n=11) | Test 1 | 140.35 | 19.99 | 107.90 | 168.49 | 1, 2 |
| | Test 2 | 133.25 | 26.67 | 84.66 | 173.47 | |
| | Test 3 | 166.45 | 37.67 | 122.84 | 225.76 | 2 |
| | Test 4 | 171.66 | 36.12 | 105.41 | 229.91 | 2 |

Table 8. Summary Table of F-ratios for Maximum Isometric Back Strength per kg of Body Weight.

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 0.64 | 0.21 | 3.0 | 0.56 |
| Error | 13.82 | 0.38 | 36.0 | |
| $Groups_W$ | 13.64 | 4.55 | 3.0 | 103.65* |
| Error (b) | 4.74 | 0.044 | 108.0 | |
| Groups x Tests | 0.36 | 0.040 | 9.0 | 0.92 |
| Error | 4.74 | 0.044 | 108.0 | |

* Denotes Significance at $P < 0.05$

Table 9. Test Main Effect Summary Table for Maximum Isometric Back Strength per kg of Body Weight.

| Test Set | Mean (kg) | Significantly Different from Test ( $\alpha$ = 0.05): |
|---|---|---|
| Test 1 | 2.08 | 3, 4 |
| Test 2 | 2.04 | 3, 4 |
| Test 3 | 2.57 | 1, 2, 4 |
| Test 4 | 2.70 | 1, 2, 3 |

Table 11. Summary Table of F-ratios for Maximum Isometric Back Strength per kg of Lean Body Weight.

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 1.84 | 0.61 | 3.0 | 1.15 |
| Error | 19.16 | 0.53 | 36.0 | |
| Tests | 18.32 | 6.11 | 3.0 | 100.01 * |
| Error | 6.60 | 0.061 | 108.0 | |
| Groups x Tests | 0.60 | 0.066 | 9.0 | 1.08 |
| Error | 6.60 | 0.061 | 108.0 | |

* Denotes Significance at $P < 0.05$

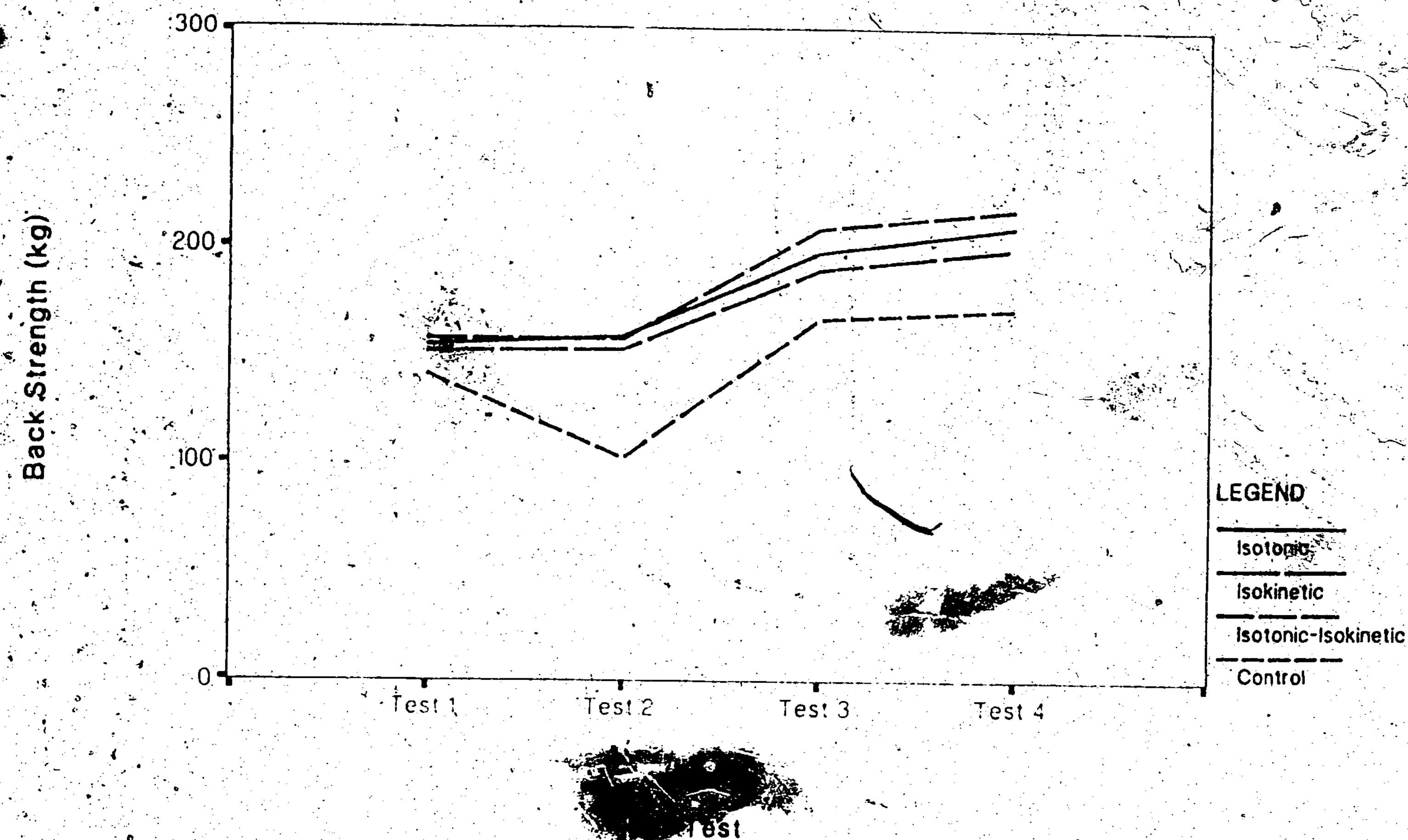
Table 12. Test Main Effect Summary Table for Maximum Isometric Back Strength per kg of Lean Body Weight.

| Test Set | Mean (kg) | Significantly Different from Test ($\alpha = 0.05$): |
|---|---|---|
| Test 1 | 2.39 | 3, 4 |
| Test 2 | 2.33 | 3, 4 |
| Test 3 | 2.97 | 1, 2 |
| Test 4 | 3.08 | 1, 2 |

Table 13. Descriptive Statistics Summary Table for Maximum Isometric Back Strength per kg of Lean Body Weight (kg).

| Group | Test | $\bar{X}$ | SD | Min. | Max. | Significantly Different from Test ( $\alpha$ = 0.05) |
|---|---|---|---|---|---|---|
| I (n=11) | Test 1 | 2.385 | 0.342 | 1.824 | 2.839 | 3, 4 |
| | Test 2 | 2.407 | 0.285 | 1.925 | 2.740 | 3, 4 |
| | Test 3 | 2.979 | 0.227 | 2.576 | 3.336 | 1, 2 |
| | Test 4 | 3.165 | 0.349 | 2.785 | 3.966 | 1, 2 |
| II (n=9) | Test 1 | 2.295 | 0.276 | 1.832 | 2.747 | 4 |
| | Test 2 | 2.203 | 0.232 | 1.842 | 2.670 | 4 |
| | Test 3 | 2.794 | 0.351 | 2.478 | 3.627 | - |
| | Test 4 | 2.927 | 0.438 | 2.543 | 3.837 | 1, 2 |
| III (n=9) | Test 1 | 2.433 | 0.388 | 1.848 | 2.961 | 3, 4 |
| | Test 2 | 2.422 | 0.462 | 1.890 | 3.375 | 3, 4 |
| | Test 3 | 3.247 | 0.615 | 2.579 | 4.289 | 1, 2 |
| | Test 4 | 3.305 | 0.655 | 2.564 | 4.402 | 1, 2 |
| IV (n=11) | Test 1 | 2.428 | 0.434 | 1.839 | 3.302 | - |
| | Test 2 | 2.266 | 0.311 | 2.031 | 3.072 | 3, 4 |
| | Test 3 | 2.883 | 0.642 | 2.131 | 4.282 | 2 |
| | Test 4 | 2.948 | 0.463 | 2.326 | 3.877 | 2 |

Figure 16. Maximum Isometric Back Strength at each Test Level for the Study Groups.



The greatest increase in strength for all groups occurred between Test 2 and 3 (Table 7, Figure 16). The mean scores of Test 2, for all groups, were slightly but non significantly lower than the Test 1 scores (Table 7). The greatest decrease at Test 2, about five percent, occurred for the Control group (Figure 16). The decrease in strength at Test 2, for all groups, may have been due to random fluctuation and/or muscle soreness which was experienced in first two to three weeks of the study.

As determined by multicomparison between cell means, by scheffe tests, the absolute back strength for all the exercise groups increased significantly at Test 3 and 4 in comparison to their Test 1 and 2 scores (Table 7). The Control group did not improve absolute back strength at Test 3 and 4 in relation to Test 1 (Table 7). The back strength per kg of body weight and lean body mass increased significantly for the Isotonic and the Isotonic-Isokinetic groups at Test 3 and 4 in relation to Test 1 and 2. Isokinetic group increased significantly at Test 4 in comparison to Test 1 and 2 (Table 10). For the Control group the maximum back strength per kg of body weight increased significantly at Test 4 in comparison to Test 1 and 2, and Test 3 in relation to Test 2 (Table 10). The maximum back strength per kg of lean body mass was significantly higher at Test 3 and 4 in relation to Test 2 (Table 13).

The improvement in the back strength for all groups may have been due to a learning effect and a training effect resulting from the exercises and/or the testing.

**Maximum Isometric Abdominal Strength**

For maximum absolute abdominal strength, abdominal strength per kg of body weight and lean body mass the test main effect was significant (Table 14, 17, and 20). For all three cases the Test 3 and 4 were significantly higher than the Test 1 and 2 (Table 15, 18, and 21). For maximum absolute strength and strength per kg of body weight the scores at Test 4 were also significantly higher than the Test 1 scores (Table 18).

For all groups the mean abdominal strength showed a tendency to increase from Test 1 to 4 (Figure 17). The greatest increase in strength occurred between Test 2 and 3 (Table 16 and Figure 17). For absolute strength, as demonstrated by Scheffe post hoc procedures, the Isotonic group showed a significant increase at Test 4 in relation to Test 1 and 2 (Table 16). The abdominal strength per kg of body weight increased significantly only for the isotonic group at Test 4 in comparison to Test 2 (Table 19).

The increase in the abdominal strength for Isotonic group may have been due to learning and training effect caused by the abdominal contractions during four sets of isotonic leg-lift exercises. The main reason for not observing a increase for Isotonic-Isokinetic group apears to be that two sets of exercises performed on the isotonic free weights were not sufficient to bring about a significant

Table 14. Summary Table of F-ratios for Maximum Absolute Isometric Abdominal Strength.

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 3543.72 | 1181.24 | 3.0 | 2.12 |
| Error | 20036.74 | 556.58 | 36.0 | |
| Tests | 5350.08 | 1783.36 | 3.0 | 49.62* |
| Error | 3881.86 | 35.94 | 108.0 | |
| Groups x Tests | 423.79 | 47.09 | 9.0 | 1.31 |
| Error | 3881.86 | 35.94 | 108.0 | |

* Denotes Significance at $P < 0.05$

Table 15. Test Main Effect Summary Table for Maximum Absolute Isometric Abdominal Strength.

| Test Set | Mean (kg) | Significantly Different from Test ( $\alpha = 0.05$): |
|---|---|---|
| Test 1 | 53.5 | 3, 4 |
| Test 2 | 52.4 | 3, 4 |
| Test 3 | 62.2 | 1, 2, 4 |
| Test 4 | 66.1 | 1, 2, 3 |

Table 16. Descriptive Statistics Summary Table for Maximum Absolute Isometric Abdominal Strength (kg).

| Group | Test | $\bar{X}$ | SD | Min. | Max. | Significantly Different from Test ($\alpha$ = 0.05) |
|---|---|---|---|---|---|---|
| I (n=11) | Test 1 | 58.10 | 8.80 | 39.84 | 74.70 | 4 |
| | Test 2 | 52.37 | 6.48 | 42.33 | 63.91 | 4 |
| | Test 3 | 65.19 | 11.48 | 48.14 | 87.15 | - |
| | Test 4 | 72.33 | 7.57 | 58.10 | 85.49 | 1, 2 |
| II (n=9) | Test 1 | 57.36 | 12.30 | 35.69 | 74.70 | - |
| | Test 2 | 55.39 | 11.18 | 37.35 | 72.73 | - |
| | Test 3 | 65.56 | 11.47 | 47.19 | 85.49 | - |
| | Test 4 | 69.47 | [illegible] | 51.10 | 85.49 | - |
| III (n=9) | Test 1 | 53.03 | 17.87 | 31.54 | 92.96 | - |
| | Test 2 | 56.45 | 11.20 | 34.96 | 72.21 | - |
| | Test 3 | 64.00 | 20.85 | 31.54 | 109.56 | - |
| | Test 4 | 67.06 | 17.04 | 44.82 | 101.26 | - |
| IV (n=11) | Test 1 | 46.10 | 14.27 | 16.60 | 58.10 | - |
| | Test 2 | 46.63 | 12.28 | 27.39 | 70.55 | - |
| | Test 3 | 54.86 | 14.72 | 26.56 | 80.51 | - |
| | Test 4 | 56.37 | 12.18 | 34.03 | 77.19 | - |

Table 17. Summary Table of F-ratios for Maximum Isometric Abdominal Strength per kg of Body Weight (kg).

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 0.06 | 0.021 | 3.0 | 0.41 |
| Error | 1.79 | 0.050 | 36.0 | |
| Tests | 0.89 | 0.30 | 3.0 | 38.66* |
| Error | 0.83 | 0.008 | 108.0 | |
| Groups x Tests | 0.10 | 0.011 | 9.0 | 1.50 |
| Error | 0.83 | 0.008 | 108.0 | |

* Denotes Significance at $P < 0.05$

[illegible] 18. Test Main Effect Summary Table for Maximum Isometric Abdominal Strength per kg of Body Weight.

| [illegible] | Mean (kg) | Significantly Different from Test ( $\alpha = 0.05$): |
|---|---|---|
| [illegible] | 0.74 | 3, 4 |
| [illegible] | 0.71 | 3, 4 |
| Test 3 | 0.84 | 1, 2, 4 |
| Test 4 | 0.90 | 1, 2, 3 |

Table 19. Descriptive Statistics Summary Table for Maximum Isometric Abdominal Strength per kg of Body Weight (kg).

| Group | Test | $\bar{X}$ | SD | Min. | Max. | Significantly Different from Test ($\alpha$ = 0.05): |
|---|---|---|---|---|---|---|
| I (n=11) | Test 1 | 0.798 | 0.125 | 0.647 | 0.988 | - |
| | Test 2 | 0.690 | 0.148 | 0.492 | 0.932 | 4 |
| | Test 3 | 0.842 | 0.103 | 0.709 | 0.981 | - |
| | Test 4 | 0.947 | 0.134 | 0.757 | 1.157 | 2 |
| II (n=9) | Test 1 | 0.770 | 0.141 | 0.508 | 1.043 | - |
| | Test 2 | 0.710 | 0.134 | 0.530 | 1.021 | - |
| | Test 3 | 0.845 | 0.159 | 0.666 | 1.192 | - |
| | Test 4 | 0.900 | 0.127 | 0.722 | 1.172 | - |
| III (n=9) | Test 1 | 0.696 | 0.156 | 0.475 | 0.927 | - |
| | Test 2 | 0.750 | 0.130 | 0.644 | 1.061 | - |
| | Test 3 | 0.830 | 0.161 | 0.584 | 1.085 | - |
| | Test 4 | 0.880 | 0.130 | 0.623 | 1.093 | - |
| IV (n=11) | Test 1 | 0.684 | 0.172 | 0.295 | 0.958 | - |
| | Test 2 | 0.704 | 0.099 | 0.513 | 0.871 | - |
| | Test 3 | 0.829 | 0.126 | 0.612 | 0.999 | - |
| | Test 4 | 0.856 | 0.102 | 0.741 | 1.100 | - |

Table 20. Summary Table of F-ratios for Maximum Isometric Abdominal Strength per kg of Lean Body Weight (kg).

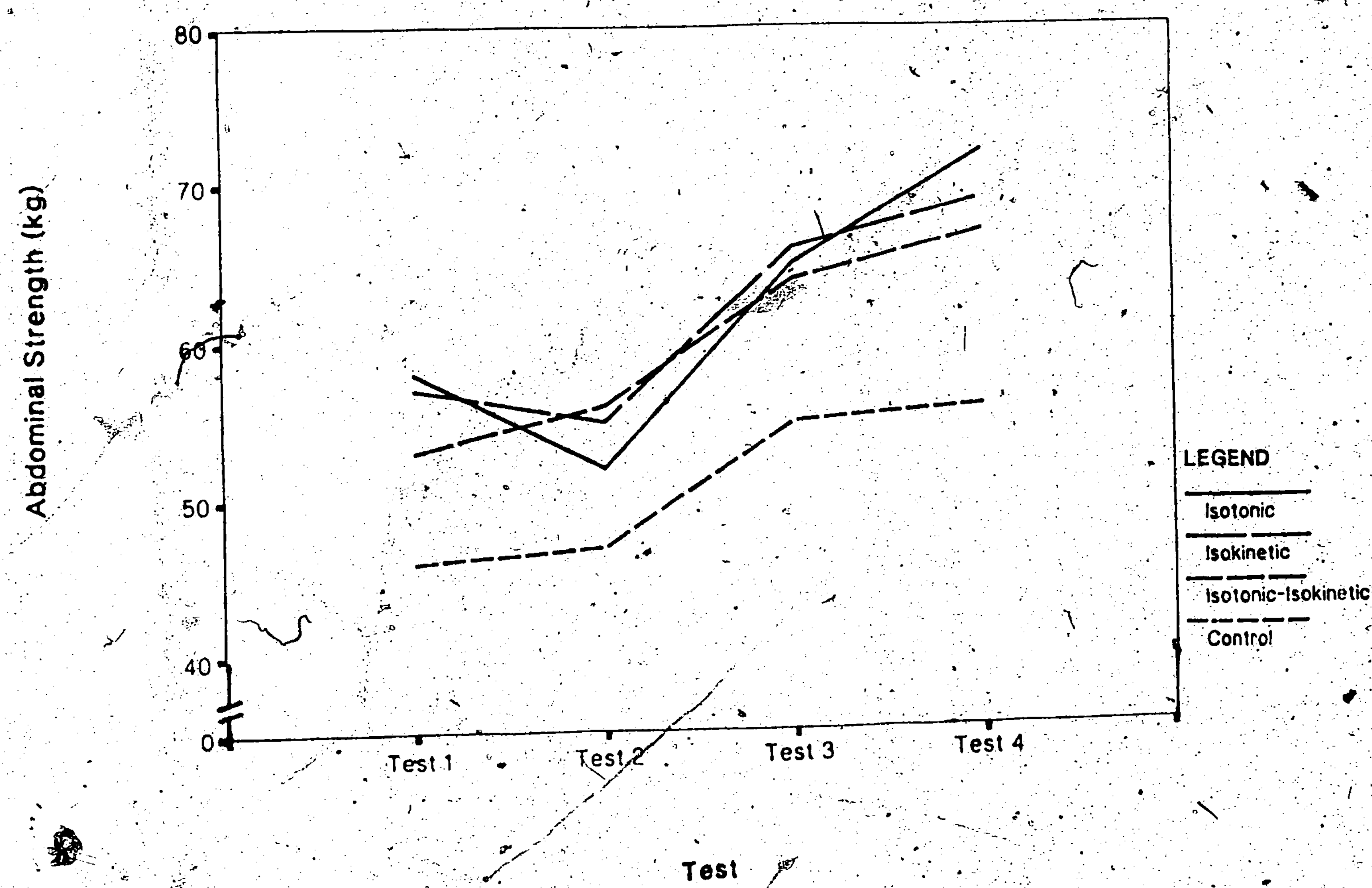
| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 0.18 | 0.062 | 3.0 | 0.95 |
| Error | 2.33 | 0.065 | 36.0 | |
| Tests | 1.12 | 0.370 | 3.0 | 36.19* |
| Error | 1.12 | 0.010 | 108.0 | |
| Groups x Tests | 0.14 | 0.016 | 9.0 | 1.53 |
| Error | 1.12 | 0.010 | 108.0 | |

* Denotes Significance at $P < 0.05$

Table 21. Test Main Effect Summary Table for Maximum Isometric Abdominal Strength per kg of Lean Body Weight.

| Test Set | Mean (kg) | Significantly Different from Test ($\alpha = 0.05$): |
|---|---|---|
| Test 1 | 0.82 | 3, 4 |
| Test 2 | 0.71 | 3, 4 |
| Test 3 | 0.84 | 1, 2 |
| Test 4 | 0.90 | 1, 2 |

Figure 17. Maximum Isometric Abdominal Strength at each Test Level for the Study Groups.



increase in abdominal strength. The overall increase in strength observed over time (tests) appears to be due to training and the learning effects.

**Vertical Jump**

For vertical jump height the test main effect was significant (Table 22). The vertical jump height scores were significantly higher for Test 3 in relation to Test 1 and 2, and Test 4 in comparison to Test 1 (Table 23).

The multicomparison between cell means, between groups or tests, did not show any significant differences (Table 41, Appendix III).

The overall increase in the vertical jump height observed over time appears to be largely from the learning effect and possibly some training effects. The main reason for not observing significant increase, for particular groups (cell means) over time, seems be that the contractile speeds for different exercises were not high enough. The cable velocity of 13 cm per second translates to limb velocity of about 30° per second. This speed would be considered a slow speed (Pipes and Wilmore, 1975). Various studies report that the vertical jump does not improve very much by the training done at low speeds in comparison to the high speeds (Pipes and Wilmore, 1975; Smith and Melton, 1981; Wathen and Shutes, 1982).

Table 22. Summary Table of F-ratios for Vertical Jump.

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 888.98 | 296.33 | 3.0 | 1.89 |
| Error | 5645.60 | 156.82 | 36.0 | |
| Tests | 220.21 | 73.40 | 3.0 | 12.99* |
| Error | 610.40 | 5.65 | 108.0 | |
| Groups x Tests | 78.77 | 8.75 | 9.0 | 1.55 |
| Error | 610.40 | 5.65 | 108.0 | |

* Denotes Significance at $P < 0.05$

Table 23. Test Main Effect Summary Table for Vertical Jump.

| Test Set | Mean (cm) | Significantly Different from Test ( $\alpha$ = 0.05): |
|---|---|---|
| Test 1 | 50.9 | 3, 4 |
| Test 2 | 52.1 | 3 |
| Test 3 | 54.0 | 1, 2 |
| Test 4 | 53.3 | 1 |

**Resting Blood Pressure**

For resting systolic, diastolic, and mean blood pressure the test main effect was significant (Table 24, 26, and 28). For all three variables the blood pressure was significantly lower at Test 2 in comparison to Test 1 and 4 (Table 25, 27, and 29). In addition, the diastolic and mean blood pressures were also lower at Test 2 in relation to Test 3 (Table 27). The multicomparison between cell means did not show any significant differences (Table 42-44, Appendix III).

The overall decrease observed at Test 2 seems to be due to a random fluctation. The main reason for not obtaining significant decrease in any of the BP variables at subsequent tests appears to be due to the short duration of exercise sessions. Stone et al. (1984) found significant decrease in SBP. Each training session, in their study, was of more than 45 minutes in duration six days a week, for eight weeks.

**Maximum Strength Heart Rate Variables**

For maximum isometric back strength heart rate the test main effect was significant, the Test 1 being significantly higher than the subsequent tests (Table 30 and 31). For maximum isotonic concentric leg-lift strength heart rate the test, and the group by test interaction was significant (Table 32). The heart rate for the isotonic concentric leg-lift strength was significantly higher at Test 1 in

Table 24. Summary Table of F-ratios for Resting Systolic Blood Pressure.

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 588.18 | 196.06 | 3.0 | 0.79 |
| Error | 8962.47 | 248.96 | 36.0 | |
| Tests | 724.56 | 241.52 | 3.0 | 8.56* |
| Error | 3045.49 | 28.20 | 108.0 | |
| Groups x Tests | 250.39 | 27.82 | 9.0 | 0.99 |
| Error | 3045.49 | 28.20 | 108.0 | |

* Denotes Significance at $P < 0.05$

Table 25. Test Main Effect Summary Table for Resting Systolic Blood Pressure.

| Test Set | Mean (mm Hg) | Significantly Different from Test ($\alpha = 0.05$): |
|---|---|---|
| Test 1 | 114.4 | 2 |
| Test 2 | 108.4 | 1, 4 |
| Test 3 | 111.7 | - |
| Test 4 | 112.0 | 2 |

Table 26. Summary Table of F-ratios for Resting Diastolic Blood Pressure.

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 606.18 | 202.06 | 3.0 | 1.15 |
| Error | 6335.70 | 175.99 | 36.0 | |
| Tests | 486.49 | 162.16 | 3.0 | 6.11* |
| Error | 2867.85 | 26.55 | 108.0 | |
| Groups x Tests | 223.77 | 24.86 | 9.0 | 0.94 |
| Error | 2867.85 | 26.55 | 108.0 | |

* Denotes Significance at $P < 0.05$

Table 27. Test Main Effect Summary Table for Resting Diastolic Blood Pressure.

| Test Set | Mean (bpm) | Significantly Different from Test ($\alpha = 0.05$): |
|---|---|---|
| Test 1 | 76.8 | 2 |
| Test 2 | 72.2 | 1, 3, 4 |
| Test 3 | 75.8 | 2 |
| Test 4 | 75.8 | 2 |

Table 28. Summary Table of F-ratios for Resting Mean Blood Pressure.

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 441.43 | 147.14 | 3.0 | 0.87 |
| Error | 6056.89 | 168.25 | 36.0 | |
| Tests | 560.15 | 186.72 | 3.0 | 9.14* |
| Error | 2206.55 | 20.43 | 108.0 | |
| Groups x Tests | 170.19 | 18.91 | 9.0 | 0.93 |
| Error | 2206.55 | 20.43 | 108.0 | |

* Denotes Significance at $P < 0.05$

Table 29. Test Main Effect Summary Table for Resting Mean Blood Pressure.

| Test Set | Mean (bpm) | Significantly Different from Test ( $\alpha = 0.05$ ): |
|---|---|---|
| Test 1 | 89.4 | 2 |
| Test 2 | 84.3 | 1, 3, 4 |
| Test 3 | 87.9 | 2 |
| Test 4 | 87.8 | 2 |

Table 30. Summary Table of F-ratios for Maximum Isometric Back Strength Heart Rate.

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 371.18 | 123.73 | 3.0 | 0.22 |
| Error | 20441.45 | 567.82 | 36.0 | |
| Tests | 3984.83 | 1328.28 | 3.0 | 10.77* |
| Error | 13317.23 | 123.31 | 108.0 | |
| Gro[illegible] Tests | 333.19 | 37.02 | 9.0 | 0.30 |
| E[illegible] | 13317.23 | 123.31 | 108.0 | |

* Denotes Significance at P < 0.05

Table 31. Test Main Effect Summary Table for Maximum Isometric Back Strength Heart Rate.

| Test Set | Mean (bpm) | Significantly Different from Test ( $\alpha$ = 0.05): |
|---|---|---|
| Test 1 | 110.0 | 2, 3, 4 |
| Test 2 | 98.6 | 1 |
| Test 3 | 98.0 | 1 |
| Test 4 | 98.9 | 1 |

Table 32. Summary Table of F-ratios for Maximum Isotonic Concentric Leg Lift Strength Heart Rate.

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 2726.66 | 908.89 | 3.0 | 1.32 |
| Error | 24843.01 | 690.08 | 36.0 | |
| Tests | 1449.17 | 483.06 | 3.0 | 3.85* |
| Error | 13554.61 | 125.51 | 108.0 | |
| Groups x Tests | 5177.48 | 575.28 | 9.0 | 4.58* |
| Error | 13554.61 | 125.51 | 108.0 | |

* Denotes Significance at $P < 0.05$

Table 33. Test Main Effect Summary Table for Maximum Isotonic Concentric Leg-Lift Strength Heart Rate.

| Test Set | Mean (bpm) | Significantly Different from Test ($\alpha$ = 0.05): |
|---|---|---|
| Test 1 | 118.6 | 4 |
| Test 2 | 111.6 | - |
| Test 3 | 113.9 | - |
| Test 4 | 110.9 | 1 |

relation to Test 4 (Table 33).

There were no significant differences found for maximum isometric abdominal strength heart rate, and isokinetic concentric and eccentric leg lift strength heart rate variables (Table 46-52, Appendix III). The multicomparison between cell means, for all strength heart rate variables, indicated no significant differences (Table 45, 47, 49, 50, and 52, Appendix III).

The overall decrease in heart rate for maximum back strength and isotonic concentric leg-lift strength appears to be due to random fluctuation since no clear trend was demonstrated over time. During all strength tests the heart rate showed a tendency to decrease somewhat with an increase in strength. The slight decrease, associated with an increase in strength, may have been due to greater resistance against blood flow caused by the muscular contraction. This would have had resulted in a greater resistance against the heart to pump the blood causing a slight decrease in the heart rate.

**Body Composition**

For body weight.the interaction between groups and tests (Table 34) was significant although the multicomparison between cell means did not show any significant differences (Table 53).

Percentage of body fat, and lean body mass did not change significantly (Table 54-57, Appendix III). Pipes and

Table 34. Summary Table of F-ratios for Body Weight.

| Source | SS | MS | DF | F-ratio |
|---|---|---|---|---|
| Groups | 3962.28 | 1320.76 | 3.0 | 2.40 |
| Error | 19781.03 | 549.47 | 36.0 | |
| Tests | 17.88 | 5.96 | 3.0 | 1.85 |
| Error | 347.17 | 3.21 | 108.0 | |
| Groups x Tests | 74.56 | 8.28 | 9.0 | 2.58 * |
| Error | 347.17 | 3.21 | 108.0 | |

* Denotes Significance at $P < 0.05$

Wilmore (1975), and Stone et al. (1983) noticed a significant increase in lean body mass and a decrease in percentage of body fat. Each training session in these studies was more than 40 minutes in duration, least three times a week. Harris and Holly (1985), and Hurley et al. (1984) found significant increases in lean body mass but not the percentage of body fat. In these two studies the intensity of exercise appears to be lower than the studies of Pipes and Wilmore (1975), and Stone et al. (1984).

The main reason for not observing a significant decrease in percentage of body fat, in this study, seems to be due to the short duration of the training sessions. Lean body mass did not appear to change significantly mainly due to limited amount of muscle mass utilized in the exercises.

## Resting Heart Rate

The RHR did not change significantly between groups at any test level or between test sets (Table 58-59, Appendix III). The RHR decreased significantly in Kanakis and Hickson's (1980) study. The subjects, in their study exercised five days per week for 10 week. Stone et al. (1984) did not obtain a significant decrease in RHR although the training regime was quite intensive. The duration of exercise, in Stone et als.' (1983) study , was more than 45 m per session, six days a week, for eight weeks.

The main reason the subjects of this study did not decrease their RHR significantly appears to be due to the short duration of the exercise sessions and not enough training sessions per week.

## Relationship Between Dependent Variables

The Pearson's moment correlation coefficient matrix of all the dependent variables is shown in Table 35. The resting BP variables correlated to a higher degree among each other, absolute abdominal and back strength, body weight and lean body mass than other dependent variables (Table 36). The increase in BP as the body weight or lean body mass increases may not be a true indication of the relationship among these particular variables. The BP may have been slightly over estimated in the larger individuals and under estimated in the smaller individuals since the same cuff was used to measure their BP.

Resting heart rate had a tendency to correlate to a higher degree with HR at peak force during various strength tests than other variables (Table 37). Perhaps similar factors influenced the HR during rest and exercise; such as hormones, motivation, anxiety, etc.

Absolute isometric back and abdominal strength corrrelated to a higher degree among each other, as well as body weight, and lean body mass (Table 38). The heavier individuals showed a tendency to have greater lean body mass. More muscle mass on the body can be expected to be one of the causative factor resulting in greater abdominal and

Table 28, Pearson Correlation Matrix for the Dependent Variables of the Study.

$.2746 \leq$ [illegible] $\leq -.2$[illegible]6: significant at $\alpha$ = 0.05 level

| | 1. Resting Systolic Blood Pressure | 2. Resting Diastolic Blood Pressure | 3. Resting Mean Blood Pressure | 4. Resting Heart Rate | 5. Isom. Max. Back Strength | 6. Isom. Max. Back St. Heart Rate | 7. Isom. Max. Back St. per kg of Body Wt. | 8. Isom. Max. Back St. per kg of Lean Body Wt. | 9. Isom. Max. Abdominal Strength | 10. Isom. Max. Abdominal St. Heart Rate | 11. Isom. Max. Abdom. St. per kg of Body Wt. | 12. Isom. Max. Abdom. St. per kg of Lean Body Wt. | 13. Isot. Max. Con. Leg Strength Heart Rate | 14. Isot. Max. Conc. Leg Strength Heart Rate | 15. Isot. Max. Ecc. Leg Strength Heart Rate | 16. Vertical Jump | 17. Body Weight | 18. Percentage of Body Fat | 19. Lean Body Weight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Resting Diastolic Blood Pressure | .6838 | | | | | | | | | | | | | | | | | | |
| Resting Mean Blood Pressure | .8653 | .9567 | | | | | | | | | | | | | | | | | |
| Resting Heart Rate | .1497 | -.0359 | .0365 | | | | | | | | | | | | | | | | |
| Isom. Max. Back, Strength | .4141 | .3506 | .3991 | -.0058 | | | | | | | | | | | | | | | |
| Isom. Max. Back St. Heart Rate | .1072 | .0168 | .0529 | .542 | .0421 | | | | | | | | | | | | | | |
| Isom. Max. Back St. per kg. of Body Wt. | -.3073 | -.2068 | -.2656 | -.0353 | .3037 | -.0083 | | | | | | | | | | | | | |
| Isom. Max. Back St. per kg. of Lean Body Wt. | -.2609 | -.1951 | -.2385 | -.0567 | .4288 | .0676 | .9065 | | | | | | | | | | | | |
| Isom. Max. Abdom. St. | .4146 | .3098 | .3710 | -.0851 | .7516 | -.0490 | -.0334 | .0010 | | | | | | | | | | | |
| Isom. Max. Abdom. St. Heart Rate | .0536 | -.0997 | -.0540 | .3276 | -.0074 | .6998 | .1214 | .1059 | .0671 | | | | | | | | | | |
| Abdom. St. per kg of Body Wt. | -.0806 | -.1048 | -.1115 | -.0575 | .4253 | -.0422 | .4628 | .3752 | .6596 | .1555 | | | | | | | | | |
| Abdom. St. per kg of Lean Body Wt. | -.0326 | -.0614 | -.0620 | .0689 | .4941 | .0458 | .4150 | .5059 | .6852 | .1552 | .5059 | | | | | | | | |
| Isot. Max. Con. Leg Strength Heart Rate | .0175 | -.1269 | -.0810 | .2867 | .1278 | .5405 | -.1328 | .1869 | .1220 | .5512 | .1031 | .1704 | | | | | | | |
| Isot. Max. Conc. Leg Heart Rate | .1323 | .0416 | .0874 | .2753 | .1008 | .6392 | -.0515 | .0749 | .3002 | .6290 | .1713 | .2997 | .6043 | | | | | | |
| Isot. Ecc. Leg St. Heart Rate | .0692 | .0334 | .0484 | .5016 | .0001 | .7707 | .0393 | .1113 | .1329 | .5760 | .1457 | .2250 | .4235 | .6457 | | | | | |
| Vertical Jump | .0429 | .1406 | .1166 | -.1272 | .2236 | -.0441 | -.3482 | .1285 | .1563 | .1264 | .2746 | .0762 | .0956 | .0272 | .0648 | | | | |
| Body Weight | .6178 | .485 | .743 | -.085 | .6699 | -.200 | -.4155 | -.2788 | .7678 | -.0761 | .0478 | .1735 | .0475 | .2545 | .0670 | -.0989 | | | |
| Percentage of Body Fat | .1330 | .0789 | .1086 | -.0512 | .1429 | .1725 | -.1444 | .2772 | .0603 | -.0274 | -.1813 | .2323 | .1570 | .2913 | .1911 | -.4932 | .3042 | | |
| Lean Body Weight | .5967 | .4811 | .5618 | -.0700 | .6529 | -.1064 | -.3679 | -.3936 | .7858 | .0865 | .1451 | -.1107 | -.0152 | .1349 | -.0139 | .1149 | .9227 | -.0815 | |

Table 36. Pearson Correlation Coefficients among Resting Systolic, Diastolic, and Mean Blood Pressure, Maximum Isometric Back and Abdominal Strength, Body Weight and Lean Body Mass.

| | Resting Systolic Blood Pressure | Resting Diastolic Blood Pressure | Resting Mean Blood-Pressure |
|---|---|---|---|
| Resting Diastolic Blood Pressure | .68 | - | .96 |
| Resting Mean Blood Pressure | .87 | - | - |
| Isom. Max. Back St. | .41 | .35 | .40 |
| Isom. Max. Abdom. St. | .41 | .31 | .37 |
| Body Weight | .62 | .49 | .57 |
| Lean Body Weight | .60 | .48 | .56 |

Table 37. Pearson Correlation Coefficient among the Heart Rate Variables.

| | Isom. Max. Abdominal St. Heart Rate | Isot. Max. Conc. Leg Strength Heart Rate | Isok. Max. Conc. Leg Strength Heart Rate | Isok. Max. Ecc. Leg Strength Heart Rate | Resting Heart Rate |
|---|---|---|---|---|---|
| Isom. Max. Back St. Heart Rate | .70 | .54 | .64 | .78 | .54 |
| Isom. Max. Abdom. St. Heart Rate | - | .55 | .63 | .58 | .33 |
| Isot. Max. Conc. Leg Strength Heart Rate | - | - | .60 | .47 | .29 |
| Isok. Max. Conc. Leg Heart Rate | - | - | - | .65 | .28 |
| Isok. Ecc. Leg. St. Heart Rate | - | - | - | - | .50 |

Table 38. Pearson Correlation Coefficients among Maximum Isometric Back and Abdominal Strength, Body Weight and Lean Body Mass.

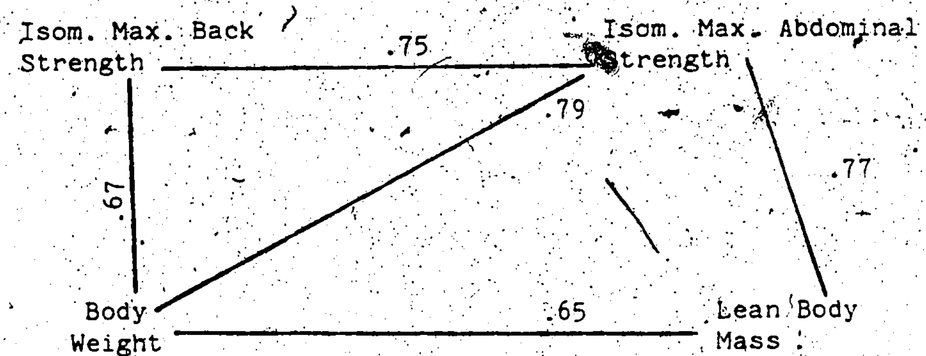
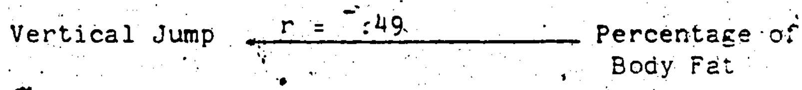



Table 39. Pearson Correlation Coefficient of Vertical Jump with Percentage of Body Fat.



back muscular strength.

The Pearson's Moment correlation coefficient among all the maximum strength HR variables was quite high in comparison to other variables (Table 37). This trend seems to indicate that similar physiological factors caused an increase in HR during peak force during all strength tests. The increase in HR during maximum strength testing may be due to several factors acting in conjunction; such as an increase in cardiac output which is usually required to meet the metabolic needs of the working muscles, hormonal, environmental, and motivational factors.

The vertical jump correlated highly negatively with percentage of body fat than it did with other variables (Table 39). The height of vertical jump decreased as one tended to have greater percentage of body fat.

## Chapter V

## SUMMARY, CONCLUSION AND RECOMMENDATIONS

The purpose of the study was to investigate the effects of isotonic concentric and eccentric, isokinetic concentric and eccentric and a combination of these lower limbs training methods on: resting BP, resting HR, back and abdominal strength, heart rate at peak force during various strength tests, vertical jump, body weight, lean body mass, and percentage of body fat.

Forty healthy volunteer male subjects ranging in age from 18-28 years participated in this study. The subjects were randomly assigned to one of the following groups: Isotonic (n = 11), Isokinetic (n = 9), Isotonic-Isokinetic (n = 9), or the Control group (n = 11). All training groups performed four sets of exercise per session, each of 72 s in total contraction time, three times a week, for 10 weeks. Four test sets were conducted: Test 1, Test 2, Test 3, and Test 4, each being at about three and a half weeks interval.

The results showed significant group by test interaction for the body weight and the maximum Isotonic concentric leg-lift strength heart rate. However, the multicomparison of cell means, done by scheffe test, did not show any significant differences.

The test main effect was significant for the:

1. maximum absolute isometric back and abdominal strength,
2. maximum isometric back and abdominal strength per kg of body weight and lean body mass,

3. maximum isometric back strength and maximum isotonic concentric leg-lift strength heart rates,
4. resting systolic, diastolic, and mean blood pressure, and
5. vertical jump.

For all maximum back and abdominal strength variables the strength scores were significantly higher at Test 3 and 4 in relation to Test 1 and 2. The maximum isometric back strength heart rate was signifcantly higher at Test 1 in comparison to the subsequent tests. The maximum isotonic concentric leg-lift heart rate was higher at Test 1 in relation to Test 4. The resting systolic blood pressure at Test 2 was higher than at Test 1 and 4. The resting diastolic and the mean blood pressure were higher at Test 2 in comparison to the other test sets. The vertical jump was significantly higher at Test 4 in relation to Test 1.

The group main effect was significant for the maximum isometric back strength. The Isotonic-Isokinetic group had significantly greater strength in comparison to the Control group.

## Conclusion

Based on the results and within limitations of the study, the following conclusions were drawn:

1. The isotonic, isokinetic, and isotonic-isokinetic lower limb training methods are equally effective for significantly improving the back strength. No one

training method was demonstrated to be superior over the others when the improvement in back strength is one of the objectives of the training program.

2. The isotonic lower limb training method does improve the abdominal strength significantly. Its superiorty over the the other training methods was not demonstrated. Therefore, all training methods appear to be equally effective for improving the abdominal musculature strength.
3. The lower limb resistance training and/or testing may decrease the maximum isometric back and maximum isotonic concentric heart rate.
4. The lower limb resistance training does not significantly decrease the resting systolic, diastolic, and mean blood pressure.
5. All three training methods of lower limb training are equally effective for improving the height of vertical jump.
6. The isotonic, isokinetic or isotonic-isokinetic training for lower limb does not significantly:
   a. decrease resting HR,
   b. decrease maximum isometric abdominal strength heart rate,
   c. decrease maximum isokinetic concentric leg lift strength heart rate,
   d. decrease maximum isokinetic eccentric leg lift strength heart rate,

e. decrease percentage of body fat,

f. increase body weight, and

g. increase lean body mass.

Recomendations

Further research is needed to investigate the direct effects of the trunk flexion and extension resistance training on the strength of the abdominal and back musculatrue. It is hypothesized that the lumbar back curvature is dependent on the the degree of strength balance of these two muscle groups. The relationship between the strength balance of abdominal and back musculature and the lumbar back curvature is also needed to be explored.

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**Physical Activity Readiness Questionnaire (PAR-Q)***

PARTICIPANT IDENTIFICATION

Appendix I. PAR Q.

# 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? |
| ☐ | ☐ | 8. Are you suffering from a back problem? |

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.



Reference: PAR-Q Validation Report, British Columbia Ministry of Health, 1978

* Produced by the British Columbia Ministry of Health and the Department of National Health & Welfare

## APPENDIX II. CONSENT FORM

I,........................... hereby volunteer to participate in a ten week-strength training study. During the course of the study, I will not participate in any resistance training exercises. However, I can continue with my normal daily activities.

I have completed the PAR Q and have no contraindication against my participating in a strength training program of this nature.

During the ten weeks of the study, I will be required to participate in four tests; one at the beginning of the training while the others at approximately three weeks intervals. The tests shall be resting blood pressure, resting heart rate, maximum isometric abdominal and back strength, maximum isokinetic-concentric abdominal and back strength, and the hydrostatic weighing.

Every effort will be made to minimize any unnecessary discomfort and risk that may be associated with these training and tests during my participation. I understand however, that just like any other physical conditioning and fitness tests, there are episodes characterized by muscle soreness and perhaps transient light headedness.

In agreeing to participate in this study and tests, I waive any legal recourse against the investigator or the Faculty of Physical Education, University of Alberta from any and all claims resultining from personal injuries or

Faculty of Physical Education, University of Alberta from any and all claims resulting from personal injuries or mishaps resulting from these tests and training.

I acknowledge that the testing and training procedures have been fully explained to me and that I can withdraw my participation from this study at any time. I hereby concent to participate on my own volition.

Date:.............. Signature:...............

Witness:..............

Appendix III. The Descriptive Summary Tables for Statistically Non-significant Parameters.

Table 40. Descriptive Statistics Summary Table for Maximum Isometric Abdominal Strength per kg of Lean Body Weight (kg).

| Group | Test | $\bar{X}$ | SD | Min. | Max. |
|---|---|---|---|---|---|
| I (n=11) | Test 1 | 0.940 | 0.134 | 0.775 | 1.159 |
| | Test 2 | 0.802 | 0.138 | 0.646 | 0.991 |
| | Test 3 | 0.983 | 0.107 | 0.830 | 1.153 |
| | Test 4 | 1.094 | 0.106 | 0.920 | 1.242 |
| II (n=9) | Test 1 | 0.867 | 0.174 | 0.577 | 1.212 |
| | Test 2 | 0.805 | 0.164 | 0.616 | 1.176 |
| | Test 3 | 0.970 | 0.183 | 0.783 | 1.368 |
| | Test 4 | 1.016 | 0.149 | 0.835 | 1.337 |
| III (n=9) | Test 1 | 0.809 | 0.193 | 0.544 | [illegible] |
| | Test 2 | 0.867 | 0.189 | 0.745 | [illegible] |
| | Test 3 | 0.982 | 0.231 | 0.689 | [illegible] |
| | Test 4 | 1.014 | 0.167 | 0.712 | 1.266 |
| IV (n=11) | Test 1 | 0.772 | 0.192 | 0.347 | 1.106 |
| | Test 2 | 0.796 | 0.096 | 0.630 | 0.941 |
| | Test 3 | 0.926 | 0.133 | 0.711 | 1.105 |
| | Test 4 | 0.959 | 0.087 | 0.821 | 1.148 |

Table 41. Descriptive Statistics Summary Table for Vertical Jump (cm).

| Group | Test | $\bar{X}$ | SD | Min. | Max. |
|---|---|---|---|---|---|
| I (n=11) | Test 1 | 49.86 | 7.93 | 37.5 | 66.5 |
| | Test 2 | 50.11 | 7.10 | 38.0 | 61.0 |
| | Test 3 | 51.41 | 7.36 | 40.0 | 64.5 |
| | Test 4 | 50.02 | 7.44 | 40.0 | 67.5 |
| II (n=9) | Test 1 | 49.42 | 6.731 | 36.0 | 56.0 |
| | Test 2 | 52.06 | 5.844 | 43.0 | 59.5 |
| | Test 3 | 55.19 | 7.016 | 43.0 | 65.9 |
| | Test 4 | 53.56 | 6.86 | 39.3 | 61.0 |
| III (n=9) | Test 1 | 54.94 | 6.49 | 46.0 | 67.0 |
| | Test 2 | 56.81 | 7.03 | 47.0 | 67.0 |
| | Test 3 | 57.50 | 6.76 | 47.5 | 67.5 |
| | Test 4 | 57.48 | 7.71 | 48.0 | 70.5 |
| IV (n=11) | Test 1 | 49.69 | 3.75 | 43.5 | 55.0 |
| | Test 2 | 50.39 | 4.66 | 41.0 | 55.3 |
| | Test 3 | 52.57 | 6.24 | 36.0 | 58.5 |
| | Test 4 | 52.84 | 5.49 | 38.5 | 60.0 |

Table 42. Descriptive Statistics Summary Table for Resting Systolic Blood Pressure (mm Hg).

| Group | Test | $\bar{X}$ | SD | Min. | Max. |
|---|---|---|---|---|---|
| I (n=11) | Test 1 | 110.591 | 9.40 | 91.0 | 195.5 |
| | Test 2 | 108.59 | 6.51 | 102.0 | 126.0 |
| | Test 3 | 110.50 | 7.96 | 100.0 | 122.5 |
| | Test 4 | 110.42 | 8.74 | 97.0 | 120.0 |
| II (n=9) | Test 1 | 117.11 | 6.81 | 109.0 | 130.0 |
| | Test 2 | 111.83 | 8.00 | 99.5 | 123.0 |
| | Test 3 | 115.26 | 6.00 | 109.0 | 126.6 |
| | Test 4 | 114.58 | 5.76 | 105.0 | 125.9 |
| III (n=9) | Test 1 | 115.72 | 13.21 | 93.5 | 136.0 |
| | Test 2 | 107.56 | 11.67 | 94.0 | 123.5 |
| | Test 3 | 114.00 | 10.79 | 97.[illegible] | 126.0 |
| | Test 4 | 112.56 | 10.58 | 94.0 | 123.5 |
| IV (n=11) | Test 1 | 115.00 | 6.85 | 100.0 | 125.0 |
| | Test 2 | 106.23 | 12.12 | 86.0 | 132.0 |
| | Test 3 | 108.05 | 9.73 | 85.0 | 122.0 |
| | Test 4 | 110.86 | 8.19 | 92.0 | 121.5 |

Table 43. Descriptive Statistics Summary Table for Resting Diastolic Blood Pressure (mm Hg).

| Group | Test | $\bar{X}$ | SD | Min. | Max. |
|---|---|---|---|---|---|
| I (n=11) | Test 1 | 77.00 | 4.68 | 69.0 | 83.0 |
| | Test 2 | 74.23 | 6.02 | 63.0 | 82.0 |
| | Test 3 | 76.77 | 4.46 | 67.0 | 81.5 |
| | Test 4 | 75.94 | 6.81 | 63.0 | 82.5 |
| II (n=9) | Test 1 | 76.22 | 4.41 | 68.5 | 81.0 |
| | Test 2 | 74.67 | 8.38 | 61.5 | 88.0 |
| | Test 3 | 74.69 | 6.29 | 64.5 | 84.0 |
| | Test 4 | 76.82 | 5.09 | 69.0 | 83.5 |
| III (n=9) | Test 1 | 79.50 | 7.46 | 68.0 | 91.0 |
| | Test 2 | 73.83 | 6.63 | 68.0 | 88.0 |
| | Test 3 | 79.36 | 8.73 | 67.0 | 97.5 |
| | Test 4 | 76.72 | 9.84 | 56.0 | 86.0 |
| IV (n=11) | Test 1 | 74.96 | 8.58 | 58.5 | 88.0 |
| | Test 2 | 66.91 | 13.65 | 53.0 | 99.0 |
| | Test 3 | 72.68 | 10.56 | 58.0 | 97.0 |
| | Test 4 | 74.09 | 9.06 | 59.5 | 88.0 |

Table 44. Descriptive Statistics Summary Table for Resting Mean Blood Pressure (mm Hg).

| Group | Test | $\bar{X}$ | SD | Min. | Max. |
|---|---|---|---|---|---|
| I (n=11) | Test 1 | 88.21 | 5.72 | 77.7 | 97.0 |
| | Test 2 | 85.67 | 5.39 | 77.3 | 96.7 |
| | Test 3 | 88.01 | 4.96 | 78.0 | 95.2 |
| | Test 4 | 87.33 | 6.46 | 74.3 | 94.2 |
| II (n=9) | Test 1 | 89.92 | 3.45 | 83.7 | 95.7 |
| | Test 2 | 87.06 | 7.81 | 75.2 | 99.3 |
| | Test 3 | 88.56 | 5.42 | 81.2 | 95.1 |
| | Test 4 | 89.42 | 4.60 | 83.3 | 96.7 |
| III (n=9) | Test 1 | 91.57 | 8.91 | 76.5 | 101.7 |
| | Test 2 | 85.06 | 7.21 | 76.7 | 99.8 |
| | Test 3 | 90.89 | 8.97 | 77.2 | 106.0 |
| | Test 4 | 88.67 | 9.82 | 68.7 | 98.5 |
| IV (n=11) | Test 1 | 88.29 | 6.57 | 79.3 | 100.3 |
| | Test 2 | 80.02 | 12.68 | 64.0 | 110.0 |
| | Test 3 | 84.86 | 8.87 | 73.8 | 105.3 |
| | Test 4 | 86.35 | 8.39 | 71.0 | 99.2 |

Table 45. Descriptive Statistics Summary Table for Maximum Isometric Back Strength Heart Rate (bpm).

| Group | Test | $\bar{X}$ | SD | Min. | Max. |
|---|---|---|---|---|---|
| I (n=11) | Test 1 | 108.63 | 14.42 | 84.43 | 130.81 |
| | Test 2 | 96.09 | 16.00 | 71.43 | 118.42 |
| | Test 3 | 95.13 | 16.77 | 65.22 | 115.38 |
| | Test 4 | 95.85 | 19.85 | 66.18 | 128.57 |
| II (n=9) | Test 1 | 108.80 | 21.92 | 83.03 | 152.03 |
| | Test 2 | 99.76 | 10.55 | 83.33 | 118.42 |
| | Test 3 | 101.01 | 13.80 | 86.53 | 121.62 |
| | Test 4 | 99.73 | 10.89 | 86.54 | 118.42 |
| III (n=9) | Test 1 | 113.79 | 15.93 | 92.21 | 138.46 |
| | Test 2 | 96.90 | 15.32 | 75.0 | 121.57 |
| | Test 3 | 97.47 | 11.33 | 80.36 | 118.42 |
| | Test 4 | 99.63 | 18.14 | 64.29 | 118.42 |
| IV (n=11) | Test 1 | 109.25 | 12.01 | 86.04 | 125.35 |
| | Test 2 | 101.68 | 13.98 | 86.54 | 125.00 |
| | Test 3 | 98.86 | 12.98 | 76.27 | 115.38 |
| | Test 4 | 100.48 | 15.85 | 63.38 | 121.62 |

Table 46. Summary Table of F-ratios for Maximum Isometric Abdominal Strength Heart Rate.

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 1013.35 | 337.78 | 3.0 | 0.52 |
| Error | 23507.13 | 652.98 | 36.0 | |
| Tests | 1018.86 | 339.62 | 3.0 | 2.31 |
| Error | 15848.01 | 146.74 | 108.6 | |
| Groups x Tests | 1368.03 | 152.00 | 9.0 | 1.04 |
| Error | 15848.01 | 146.74 | 108.6 | |

Table 47. Descriptive Statistics Summary Table for Maximum Isometric Abdominal Strength Heart Rate (bpm).

| Group | Test | $\bar{X}$ | SD | Min. | Max. |
|---|---|---|---|---|---|
| I (n=11) | Test 1 | 105.931 | 18.26 | 79.79 | 136.36 |
| | Test 2 | 101.66 | 15.28 | 72.58 | 121.31 |
| | Test 3 | 97.56 | 13.25 | 78.95 | 118.42 |
| | Test 4 | 96.83 | 13.23 | 83.33 | 121.62 |
| II (n=9) | Test 1 | 102.01 | 23.00 | 77.45 | 149.01 |
| | Test 2 | 105.29 | 24.99 | 66.18 | 149.01 |
| | Test 3 | 91.07 | 20.21 | 62.50 | 132.35 |
| | Test 4 | 100.34 | 17.60 | 66.38 | 121.62 |
| III (n=9) | Test 1 | 101.00 | 19.85 | 69.77 | 133.14 |
| | Test 2 | 102.67 | 6.15 | 73.77 | 125.00 |
| | Test 3 | 99.75 | 10.37 | 86.54 | 115.38 |
| | Test 4 | 99.87 | 13.44 | 84.91 | 118.42 |
| IV (n=11) | Test 1 | 106.24 | 14.78 | 91.84 | 132.35 |
| | Test 2 | 103.82 | 15.04 | 78.95 | 132.35 |
| | Test 3 | 101.20 | 9.95 | 83.33 | 115.38 |
| | Test 4 | 112.37 | 12.61 | 95.74 | 136.36 |

Table 48. Summary Table of F-ratios for Maximum Isokinetic Concentric Leg-lift Strength Heart Rate.

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 1270.51 | 423.50 | 3.0 | 0.71 |
| Error | 21370.55 | 593.63 | 36.0 | |
| Tests | 358.79 | 119.60 | 3.0 | 0.63 |
| Error | 20595.30 | 190. | 108.0 | |
| Groups x Tests | 1437.31 | 159.03 | 9.0 | 0.83 |
| Error | 20595.30 | 190.70 | 108.0 | |

Table 49. Descriptive Statistics Summary Table for Maximum Isokinetic-Concentric Leg Lift Strength Heart Rate (bpm).

| Group | Test | $\bar{X}$ | SD | Min. | Max. |
|---|---|---|---|---|---|
| I (n=11) | Test 1 | 115.371 | 14.782 | 82.95 | 136.33 |
| | Test 2 | 107.55 | 17.96 | 86.54 | 132.75 |
| | Test 3 | 110.58 | 20.10 | 86.54 | 150.00 |
| | Test 4 | 107.85 | 21.33 | 84.91 | 145.16 |
| II (n=9) | Test 1 | 104.61 | 17.73 | 69.98 | 135.14 |
| | Test 2 | 115.33 | 15.42 | 95.74 | 145.86 |
| | Test 3 | 111.11 | 17.13 | 88.24 | 141.64 |
| | Test 4 | 110.15 | 27.26 | 77.59 | 160.71 |
| III (n=9) | Test 1 | 111.48 | 16.54 | 83.96 | 134.42 |
| | Test 2 | 117.69 | 19.60 | 88.24 | 140.63 |
| | Test 3 | 113.69 | 17.85 | 93.75 | 150.00 |
| | Test 4 | 110.94 | 11.54 | 91.84 | 121.62 |
| IV (n=11) | Test 1 | 109.78 | 15.97 | 84.43 | 142.86 |
| | Test 2 | 103.37 | 14.30 | 84.91 | 136.36 |
| | Test 3 | 108.42 | 9.14 | 93.75 | 125.00 |
| | Test 4 | 100.89 | 9.87 | 90.00 | 115.38 |

**Table 50. Descriptive Statistics Summary Table for Maximum Isotonic-Concentric Leg Lift Strength Heart Rate (bpm).**

| Group | Test | $\bar{X}$ | SD | Min. | Max. |
|---|---|---|---|---|---|
| I (n=11) | Test 1 | 121.75 | 18.20 | 90.00 | 157.89 |
| | Test 2 | 106.22 | 12.70 | 90.00 | 133.00 |
| | Test 3 | 111.28 | 13.06 | 91.84 | 136.36 |
| | Test 4 | 99.97 | 23.05 | 40.63 | 125.00 |
| II (n=9) | Test 1 | 129.74 | 18.63 | 100.00 | 157.89 |
| | Test 2 | 111.38 | 11.70 | 88.24 | 126.79 |
| | Test 3 | 120.75 | 14.60 | 97.61 | 145.16 |
| | Test 4 | 118.29 | 17.38 | 94.29 | 150.00 |
| III (n=9) | Test 1 | 106.83 | 17.19 | 77.58 | 132.00 |
| | Test 2 | 114.956 | 16.39 | 93.75 | 140.63 |
| | Test 3 | 122.37 | 16.50 | 102.27 | 155.29 |
| | Test 4 | 119.79 | 17.92 | 93.75 | 140.63 |
| IV (n=11) | Test 1 | 115.83 | 13.09 | 90.91 | 134.33 |
| | Test 2 | 114.32 | 16.05 | 81.08 | 136.36 |
| | Test 3 | 103.84 | 16.01 | 84.91 | 126.36 |
| | Test 4 | 108.38 | 15.32 | 76.27 | 131.11 |

Table 51. Summary Table of F-ratios for Maximum Isokinetic Eccentric Leg-lift Strength Heart Rate.

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 187.16 | 62.39 | 3.0 | 0.07 |
| Error | 3159.88 | 877.77 | 36.0 | |
| Tests | 1134.51 | 378.17 | 3.0 | 2.25 |
| Error | 18112.19 | 167.71 | 108.0 | |
| Groups x Tests | 2650.62 | 294.51 | 9.0 | 1.76 |
| Error | 18112.19 | 167.71 | 108.0 | |

Table 52. Descriptive Statistics Summary Table for Maximum Isokinetic-Eccentric Leg Lift Strength Heart Rate (bpm).

| Group | Test | $\bar{X}$ | SD | Min. | Max. |
|---|---|---|---|---|---|
| I (n=11) | Test 1 | 112.54 | 18.82 | 79.65 | 142.86 |
| | Test 2 | 107.99 | 16.77 | 84.91 | 138.31 |
| | Test 3 | 110.74 | 16.99 | 93.75 | 140.63 |
| | Test 4 | 103.48 | 16.62 | 83.33 | 145.16 |
| II (n=9) | Test 1 | 109.67 | 20.10 | 86.04 | 145.63 |
| | Test 2 | 106.57 | 28.88 | 70.31 | 155.17 |
| | Test 3 | 111.43 | 21.69 | 77.59 | 140.63 |
| | Test 4 | 116.76 | 28.80 | 68.18 | 155.17 |
| III (n=9) | Test 1 | 112.67 | 17.29 | 79.65 | 136.36 |
| | Test 2 | 96.89 | 11.82 | 78.95 | 109.76 |
| | Test 3 | 115.01 | 13.08 | 102.27 | 136.36 |
| | Test 4 | 108.21 | 19.98 | 76.27 | 140.63 |
| IV (n=11) | Test 1 | 116.20 | 20.12 | 87.38 | 149.50 |
| | Test 2 | 109.82 | 17.55 | 78.95 | 134.33 |
| | Test 3 | 103.84 | 13.00 | 80.36 | 121.62 |
| | Test 4 | 105.14 | 7.24 | 91.84 | 115.38 |

Table 53. Descriptive Statistics Summary Table for Body Weight (kg).

| Group | Test | $\bar{X}$ | SD | Min. | Max. |
|---|---|---|---|---|---|
| I (n=11) | Test 1 | 77.67 | 14.02 | 63.6 | 115.5 |
| | Test 2 | 77.87 | 13.90 | 63.4 | 114.7 |
| | Test 3 | 77.87 | 14.13 | 64.0 | 115.3 |
| | Test 4 | 77.69 | 13.81 | 63.1 | 112.9 |
| II (n=9) | Test 1 | 74.29 | 6.82 | 65.0 | 88.6 |
| | Test 2 | 77.94 | 7.11 | 70.8 | 90.6 |
| | Test 3 | 77.84 | 7.00 | 70.9 | 89.8 |
| | Test 4 | 77.19 | 6.66 | 70.8 | 88.5 |
| III (n=9) | Test 1 | 75.62 | 14.11 | 53.0 | 100.3 |
| | Test 2 | 75.92 | 14.51 | 52.7 | 102.2 |
| | Test 3 | 76.13 | 14.18 | 54.0 | 101.0 |
| | Test 4 | 76.71 | 14.07 | 54.5 | 100.2 |
| IV (n=11) | Test 1 | 66.42 | 10.25 | 46.0 | 80.9 |
| | Test 2 | 65.47 | 10.43 | 42.8 | 81.0 |
| | Test 3 | 66.11 | 10.42 | 43.4 | 80.6 |
| | Test 4 | 65.57 | 10.55 | 43.7 | 82.7 |

Table 54. Summary Table of F-ratios for Lean Body Weight.

| Source | SS | MS | DF | F-ratio |
|---|---|---|---|---|
| Groups | 2181.77 | 727.06 | 3.0 | 2.02 |
| Error | 12966.56 | 360.18 | 36.0 | |
| Tests | 23.4 | 7.80 | 3.0 | 2.12 |
| Error | 397.64 | 3.68 | 108.0 | |
| Groups x Tests | 49.29 | 5.48 | 9.0 | 1.49 |
| Error | 397.6[illegible] | 3.68 | 108.0 | |

Table 55. Descriptive Statistics Summary Table for Lean Body Weight (kg).

| Group | Test | $\bar{X}$ | SD | Min. | Max. |
|---|---|---|---|---|---|
| I (n=11) | Test 1 | 65.43 | 8.21 | 54.96 | 83.71 |
| | Test 2 | 66.18 | 8.66 | 56.59 | 87.40 |
| | Test 3 | 66.26 | 8.88 | 57.15 | 88.44 |
| | Test 4 | 66.50 | 8.02 | 55.96 | 85.51 |
| II (n=9) | Test 1 | 65.98 | 4.29 | 61.63 | 74.25 |
| | Test 2 | 68.93 | 5.65 | 60.84 | 77.43 |
| | Test 3 | 67.81 | 5.67 | 60.28 | 77.60 |
| | Test 4 | 68.44 | 5.46 | 61.22 | 77.84 |
| III (n=9) | Test 1 | 65.31 | 12.34 | 45.37 | 87.97 |
| | Test 2 | 66.13 | 12.90 | 46.56 | 88.43 |
| | Test 3 | 65.24 | 14.54 | 43.74 | 89.14 |
| | Test 4 | 66.77 | 12.40 | 47.58 | 86.58 |
| IV (n=11) | Test 1 | 58.96 | 10.43 | 38.83 | 76.19 |
| | Test 2 | 57.87 | 10.00 | 38.32 | 74.98 |
| | Test 3 | 58.45 | 9.93 | 37.33 | 73.64 |
| | Test 4 | 58.46 | 10.33 | 37.46 | 76.62 |

Table 56. Summary Table of F-ratios for Percentage of Body Fat.

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 278.81 | 92.94 | 3.0 | 0.95 |
| Error | 3520.66 | 97.80 | 36.0 | |
| Tests | 15.82 | 5.27 | 3.0 | 1.23 |
| Error | 464.54 | 4.30 | 108.0 | |
| Groups x Tests | 27.60 | 3.07 | 9.0 | 0.71 |
| Error | 464.54 | 4.30 | 108.0 | |

Table 57. Descriptive Statistics Summary Table for Percentage of Body Fat.

| Group | Test | $\bar{X}$ | SD | Min. | Max. |
|---|---|---|---|---|---|
| I (n=11) | Test 1 | 14.99 | 6.98 | 5.08 | 27.67 |
| | Test 2 | 14.30 | 7.33 | 5.22 | 28.69 |
| | Test 3 | 14.24 | 6.10 | 5.09 | 25.18 |
| | Test 4 | 14.55 | 6.29 | 6.62 | 25.48 |
| II (n=9) | Test 1 | 10.93 | 4.49 | 1.72 | 16.19 |
| | Test 2 | 11.47 | 3.38 | 6.47 | 15.56 |
| | Test 3 | 12.72 | 3.00 | 7.14 | 17.56 |
| | Test 4 | 11.27 | 2.61 | 6.47 | 15.10 |
| III (n=9) | Test 1 | 13.59 | 4.23 | 8.03 | 19.92 |
| | Test 2 | 12.85 | 5.30 | 2.39 | 19.36 |
| | Test 3 | 14.66 | 7.59 | 0.56 | 28.18 |
| | Test 4 | 12.86 | 5.49 | 1.07 | 19.49 |
| IV (n=11) | Test 1 | 11.46 | 4.53 | 5.75 | 18.36 |
| | Test 2 | 11.69 | 4.30 | 5.38 | 18.52 |
| | Test 3 | 11.70 | 4.02 | 4.09 | 16.64 |
| | Test 4 | 10.99 | 4.40 | 4.35 | 17.15 |

Table 58. Summary Table of F-ratios for Resting Heart Rate.

| Source | SS | MS | df | F-ratio |
|---|---|---|---|---|
| Groups | 2238.86 | 746.29 | 3.0 | 2.70 |
| Error | 9934.19 | 275.95 | 36.0 | |
| Tests | 175.22 | 58.41 | 3.0 | 0.55 |
| Error | 11488.71 | 106.38 | 108.0 | |
| Groups x Tests | 785.20 | 87.24 | 9.0 | 0.82 |
| Error | 11488.71 | 106.38 | 108.0 | |

Table 59. Descriptive Statistics Summary Table for Resting Heart Rate (bpm).

| Group | Test | $\bar{X}$ | SD | Min. | Max. |
|---|---|---|---|---|---|
| I (n=11) | Test 1 | 71.64 | 8.10 | 59.80 | 86.96 |
| | Test 2 | 75.51 | 14.24 | 55.56 | 104.65 |
| | Test 3 | 67.73 | 9.50 | 50.56 | 80.36 |
| | Test 4 | 69.15 | 12.75 | 49.45 | 84.91 |
| II (n=9) | Test 1 | 82.45 | 12.96 | 59.41 | 97.40 |
| | Test 2 | 76.72 | 10.75 | 53.68 | 86.54 |
| | Test 3 | 81.35 | 13.72 | 61.64 | 102.27 |
| | Test 4 | 79.78 | 14.26 | 53.70 | 107.00 |
| III (n=9) | Test 1 | 72.16 | 9.96 | 58.98 | 86.96 |
| | Test 2 | 67.85 | 7.37 | 56.25 | 76.27 |
| | Test 3 | 74.17 | 19.76 | 54.87 | 107.06 |
| | Test 4 | 66.79 | 12.62 | 48.91 | 86.54 |
| IV (n=11) | Test 1 | 74.30 | 12.16 | 60.40 | 104.00 |
| | Test 2 | 70.65 | 11.22 | 55.56 | 91.84 |
| | Test 3 | 72.44 | 11.35 | 50.6 | 90.50 |
| | Test 4 | 73.23 | 10.78 | 59.21 | 93.75 |

Appendix IV. Raw Data on Dependent Variables of the Study.

Table 1. Pre-test Raw Data on Resting Blood Pressure and Resting Heart Rate

| Subject Number | Age (Years) | Resting Systolic Blood Pressure | Resting Diastolic Blood Pressure | Resting Mean Blood Pressure | Resting Heart Rate |
|---|---|---|---|---|---|
| Group I | | | | | |
| 1 | 24 | 112.0 | 69.0 | 83.3 | 74.5 |
| 2 | 25 | 116.0 | 77.0 | 90.0 | 73.41 |
| 3 | 19 | 101.5 | 76.5 | 84.4 | 77.85 |
| 4 | 25 | 107.5 | 74.5 | 85.5 | 64.29 |
| 5 | 19 | 115.0 | 80.0 | 92.0 | 76.27 |
| 6 | 19 | 91.0 | 71.0 | 77.7 | 73.69 |
| 7 | 18 | 120.0 | 81.5 | 94.3 | 74.26 |
| 8 | 28 | 105.0 | 73.0 | 83.7 | 59.80 |
| 9 | 25 | 114.0 | 82.0 | 92.7 | 86.96 |
| 10 | 22 | 125.5 | 83.0 | 97.0 | 60.89 |
| 11 | 18 | 109.0 | 78.5 | 89.3 | 66.18 |
| Group II | | | | | |
| 1 | 23 | 115.0 | 77.0 | 89.7 | 74.14 |
| 2 | 18 | 111.0 | 70.0 | 83.7 | 68.18 |
| 3 | 20 | 120.5 | 79.5 | 93.2 | 97.19 |
| 4 | 20 | 119.0 | 75.5 | 90.0 | 97.40 |
| 5 | 24 | 111.0 | 80.0 | 90.3 | 90.36 |
| 6 | 21 | 109.0 | 75.5 | 86.7 | 83.64 |
| 7 | 19 | 115.0 | 79.0 | 91.0 | 59.51 |
| 8 | 18 | 130.0 | 68.5 | 89.0 | 83.48 |
| 9 | 28 | 123.5 | 81.0 | 95.7 | 88.24 |
| Group III | | | | | |
| 1 | 28 | 122.0 | 81.0 | 94.7 | 69.23 |
| 2 | 19 | 114.0 | 78.0 | 90.0 | 64.29 |
| 3 | 23 | 118.0 | 80.0 | 92.6 | 86.96 |

Table 1. (Continued)

| | | | | | |
|---|---|---|---|---|---|
| **Group III** | | | | | |
| 4 | 28 | 101.0 | 74.0 | 83.0 | 63.38 |
| 5 | 25 | 108.0 | 72.5 | 84.3 | 70.75 |
| 6 | 20 | 127.0 | 89.0 | 101.7 | 70.20 |
| 7 | 21 | 136.0 | 82.0 | 100.0 | 79.81 |
| 8 | 18 | 93.5 | 68.0 | 76.5 | 85.88 |
| 9 | 28 | 122.0 | 91.0 | 101.3 | 58.98 |
| **Group IV** | | | | | |
| 1 | 25 | 117.5 | 80.0 | 82.5 | 78.13 |
| 2 | 25 | 118.0 | 80.0 | 92.7 | 70.53 |
| 3 | 20 | 124.0 | 58.5 | 80.3 | 69.98 |
| 4 | 25 | 115.5 | 66.0 | 82.5 | 62.50 |
| 5 | 18 | 109.5 | 75.0 | 86.5 | 71.77 |
| 6 | 18 | 113.0 | 79.0 | 90.3 | 79.51 |
| 7 | 22 | 100.0 | 69.0 | 79.3 | 68.91 |
| 8 | 28 | 115.0 | 79.5 | 91.3 | 67.16 |
| 9 | 23 | 125.0 | 88.0 | 100.3 | 60.40 |
| 10 | 21 | 111.5 | 68.0 | 82.5 | 104.0 |
| 11 | 21 | 116.0 | 81.5 | 93.0 | 84.43 |

Table 2. Mid-test I Raw Data on Resting Blood Pressure and Resting Heart Rate

| Subject Number | Age (Years) | Resting Systolic Blood Pressure | Resting Diastolic Blood Pressure | Resting Mean Blood Pressure | Resting Heart Rate |
|---|---|---|---|---|---|
| Group I | | | | | |
| 1 | 25 | 105.0 | 79.0 | 87.0 | 104.65 |
| 2 | 25 | 107.0 | 70.0 | 82.3 | 90.00 |
| 3 | 19 | 107.5 | 75.0 | 85.8 | 64.29 |
| 4 | 25 | 111.0 | 69.0 | 83.0 | 76.27 |
| 5 | 19 | 102.0 | 72.5 | 82.3 | 60.81 |
| 6 | 19 | 104.5 | 71.5 | 82.5 | 88.24 |
| 7 | 18 | 107.0 | 82.0 | 90.3 | 77.59 |
| 8 | 28 | 113.0 | 80.0 | 91.0 | 70.31 |
| 9 | 25 | 105.5 | 72.5 | 83.5 | 70.31 |
| 10 | 22 | 126.0 | 82.0 | 96.7 | 55.56 |
| 11 | 18 | 106.0 | 63.0 | 77.3 | 72.58 |
| Group II | | | | | |
| 1 | 23 | 112.5 | 67.5 | 82.5 | 86.54 |
| 2 | 18 | 114.0 | 74.0 | 87.3 | 66.18 |
| 3 | 20 | 122.0 | 88.0 | 99.3 | 84.91 |
| 4 | 20 | 102.5 | 61.5 | 75.2 | 80.36 |
| 5 | 24 | 99.5 | 66.5 | 77.5 | 84.63 |
| 6 | 21 | 108.5 | 81.0 | 90.2 | 77.91 |
| 7 | 19 | 108.5 | 74.0 | 85.5 | 53.68 |
| 8 | 18 | 123.0 | 79.5 | 94.0 | 73.77 |
| 9 | 28 | 116.0 | 80.0 | 92.0 | 82.51 |
| Group III | | | | | |
| 1 | 28 | 112.0 | 81.0 | 91.3 | 71.43 |
| 2 | 19 | 115.0 | 70.0 | 85.0 | 56.25 |
| 3 | 23 | 98.0 | 73.0 | 81.3 | 72.58 |

Table 2. (Continued)

| | | | | | |
|---|---|---|---|---|---|
| Group III | | | | | |
| 4 | 28 | 96.0 | 72.5 | 80.3 | 57.69 |
| 5 | 25 | 94.0 | 68.0 | 76.7 | 65.22 |
| 6 | 20 | 115.5 | 74.0 | 87.8 | 71.43 |
| 7 | 21 | 119.0 | 68.0 | 85.0 | 75.46 |
| 8 | 18 | 95.0 | 70.0 | 78.3 | 76.27 |
| 9 | 28 | 123.5 | 88.0 | 99.8 | 64.39 |
| Group IV | | | | | |
| 1 | 25 | 105.0 | 70.0 | 81.7 | 63.38 |
| 2 | 25 | 98.0 | 68.0 | 78.0 | 72.58 |
| 3 | 20 | 94.0 | 55.0 | 68.0 | 67.37 |
| 4 | 25 | 107.0 | 59.0 | 75.0 | 55.56 |
| 5 | 18 | 115.5 | 80.0 | 91.8 | 69.16 |
| 6 | 18 | 109.0 | 57.5 | 74.7 | 91.84 |
| 7 | 22 | 86.0 | 53.0 | 64.0 | 66.3 |
| 8 | 28 | 114.0 | 73.5 | 87.0 | 71.43 |
| 9 | 23 | 132.0 | 99.0 | 110.0 | 90.91 |
| 10 | 21 | 106.5 | 56.0 | 72.8 | 63.38 |
| 11 | 21 | 101.5 | 65.0 | 77.2 | 65.22 |

Table 3. Mid-test II Raw Data on Resting Blood Pressure and Resting Heart Rate

| Subject Number | Age (Years) | Resting Systolic Blood Pressure | Resting Diastolic Blood Pressure | Resting Mean Blood Pressure | Resting Heart Rate |
|---|---|---|---|---|---|
| Group I | | | | | |
| 1 | 24 | 109.0 | 74.5 | 86.0 | 76.27 |
| 2 | 25 | 113.0 | 76.5 | 88.7 | 64.29 |
| 3 | 19 | 100.0 | 81.0 | 87.3 | 50.56 |
| 4 | 25 | 112.5 | 80.5 | 91.2 | 59.21 |
| 5 | 19 | 100.5 | 71.0 | 80.7 | 70.31 |
| 6 | 19 | 100.0 | 67.0 | 78.0 | 75.00 |
| 7 | 18 | 122.5 | 81.5 | 95.2 | 77.59 |
| 8 | 28 | 107.0 | 79.5 | 88.7 | 60.00 |
| 9 | 25 | 117.0 | 77.0 | 90.3 | 80.36 |
| 10 | 22 | 120.0 | 78.0 | 92.0 | 60.00 |
| 11 | 18 | 114.0 | 78.0 | 90.0 | 71.43 |
| Group II | | | | | |
| 1 | 23 | 114.7 | 69.3 | 84.4 | 97.83 |
| 2 | 18 | 112.0 | 79.0 | 93.0 | 73.77 |
| 3 | 20 | 110.5 | 74.0 | 86.2 | 86.54 |
| 4 | 20 | 114.5 | 64.5 | 81.2 | 86.54 |
| 5 | 24 | 115.5 | 84.0 | 94.5 | 78.95 |
| 6 | 21 | 109.0 | 68.0 | 81.7 | 64.29 |
| 7 | 19 | 111.0 | 77.5 | 88.7 | 61.64 |
| 8 | 18 | 126.6 | 79.4 | 95.1 | 80.34 |
| 9 | 28 | 123.5 | 76.5 | 92.2 | 102.27 |
| Group III | | | | | |
| 1 | 28 | 122.5 | 78.5 | 93.2 | 55.56 |
| 2 | 19 | 122.0 | 83.0 | 96.0 | 93.75 |
| 3 | 23 | 116.0 | 80.5 | 92.3 | 77.59 |

Table 5. (Continued)

| | | | | | |
|---|---|---|---|---|---|
| Group III | | | | | |
| 4 | 28 | 103.5 | 75.0 | 84.5 | 55.56 |
| 5 | 25 | 87.5 | 67.0 | 77.2 | 54.87 |
| 6 | 20 | 115.0 | 77.7 | 90.0 | 107.0 |
| 7 | 21 | 126.0 | 84.0 | 98.0 | 81.82 |
| 8 | 10 | 100.5 | 71.0 | 80.8 | 86.54 |
| 9 | 28 | 123.0 | 97.5 | 106.0 | 54.87 |
| Group IV | | | | | |
| 1 | 25 | 99.5 | 68.0 | 78.5 | 71.43 |
| 2 | 25 | 113.0 | 78.5 | 90.0 | 77.59 |
| 3 | 20 | 105.5 | 58.0 | 73.8 | 59.21 |
| 4 | 25 | 114.5 | 63.0 | 80.2 | 72.58 |
| 5 | 18 | 113.5 | 77.0 | 89.2 | 71.43 |
| 6 | 18 | 114.0 | 74.0 | 87.3 | 71.79 |
| 7 | 22 | 85.0 | 62.0 | 74.0 | 86.54 |
| 8 | 28 | 108.5 | 75.0 | 86.2 | 66.18 |
| 9 | 23 | 122.0 | 97.0 | 105.3 | 90.50 |
| 10 | 21 | 108.6 | 76.5 | 87.0 | 50.60 |
| 11 | 21 | 105.0 | 70.5 | 82.0 | 78.95 |

Table 4. Post-test Raw Data on Resting Blood Pressure and Resting Heart Rate

| Subject Number | Age (Years) | Resting Systolic Blood Pressure | Resting Diastolic Blood Pressure | Resting Mean Blood Pressure | Resting Heart Rate |
|---|---|---|---|---|---|
| Group I | | | | | |
| 1 | 24 | 110.5 | 82.0 | 91.5 | 84.90 |
| 2 | 25 | 120 | 68.0 | 85.3 | 76.27 |
| 3 | 19 | 100.1 | 79.3 | 86.3 | 51.98 |
| 4 | 25 | 118.5 | 77.5 | 91.5 | 49.45 |
| 5 | 19 | 109.0 | 79.0 | 88.0 | 76.27 |
| 6 | 19 | 97.0 | 66.5 | 76.5 | 54.88 |
| 7 | 18 | 117.5 | 82.5 | 94.2 | 78.95 |
| 8 | 28 | 113.0 | 79.0 | 90.3 | 72.58 |
| 9 | 25 | 118.0 | 77.0 | 90.7 | 84.91 |
| 10 | 22 | 113.0 | 81.5 | 92.0 | 64.29 |
| 11 | 18 | 97.0 | 63.0 | 74.3 | 66.18 |
| Group II | | | | | |
| 1 | 23 | 114.0 | 72.0 | 86.0 | 107.00 |
| 2 | 18 | 111.3 | 76.8 | 88.3 | 72.20 |
| 3 | 20 | 116.5 | 71.5 | 86.5 | 84.90 |
| 4 | 20 | 112.0 | 69.0 | 83.3 | 76.27 |
| 5 | 24 | 119.0 | 83.5 | 95.5 | 86.54 |
| 6 | 21 | 105.0 | 76.5 | 86.0 | 73.77 |
| 7 | 19 | 115.0 | 81.0 | 92.3 | 53.57 |
| 8 | 18 | 125.9 | 82.1 | 96.7 | 78.77 |
| 9 | 28 | 112.5 | 79.0 | 90.16 | 84.91 |
| Group III | | | | | |
| 1 | 28 | 121.0 | 77.0 | 91.7 | 64.29 |
| 2 | 19 | 117.0 | 83.0 | 94.3 | 59.21 |
| 3 | 23 | 106.5 | 79.5 | 88.5 | 86.54 |

Table 4 (Continued)

| | | | | | |
|---|---|---|---|---|---|
| Group III | | | | | |
| 4 | 28 | 115.0 | 80.0 | 91.5 | 77.59 |
| 5 | 25 | 94.0 | 56.0 | 68.67 | 50.60 |
| 6 | 20 | 120.0 | 80.0 | 93.5 | 69.23 |
| 7 | 21 | 118.0 | 84.0 | 95.3 | 77.59 |
| 8 | 18 | 98.0 | 65.0 | 76.0 | 67.16 |
| 9 | 28 | 123.5 | 86.0 | 98.5 | 48.91 |
| Group IV | | | | | |
| 1 | 25 | 104.0 | 68.0 | 80.0 | 93.75 |
| 2 | 25 | 109.0 | 78.5 | 88.7 | 69.23 |
| 3 | 20 | 108.5 | 59.5 | 75.8 | 72.58 |
| 4 | 25 | 116.5 | 78.0 | 90.8 | 86.54 |
| 5 | 18 | 116.0 | 84.5 | 95.0 | 80.36 |
| 6 | 18 | 120.0 | 77.5 | 91.7 | 72.58 |
| 7 | 22 | 92.0 | 60.5 | 71.0 | 70.31 |
| 8 | 28 | 111.5 | 77.5 | 88.8 | 77.58 |
| 9 | 23 | 121.5 | 88.0 | 99.2 | 60.00 |
| 10 | 21 | 109.0 | 69.0 | 82.3 | 63.38 |
| 11 | 21 | 111.5 | 74.0 | 86.5 | 59.21 |

Table 5 Pre-test Raw Data Pertaining to Back and Abdominal Variables

| Subject Number | Age (Years) | Isom. Max. Back Strength | Isom. Max. Back St. Heart Rate | Isom. Max. Back St. per kg of Body Weight | Isom. Max. Back St. per kg of Lean Body Weight | Isom. Max. Abdom. St. | Isom. Max. Abdom. St. Heart Rate | Isom. Max. Abdom. St. per kg of Body Weight | Isom. Max. Abdom. St. per kg of Lean Body Wt. |
|---|---|---|---|---|---|---|---|---|---|
| Group I | | | | | | | | | |
| [illegible] | 24 | 166.83 | 119.05 | 2.350 | 2.746 | 67.23 | 117.19 | 0.947 | 1.107 |
| 2 | 25 | 151.06 | 87.00 | 1.907 | 2.274 | 51.46 | 83.33 | 0.650 | 0.775 |
| 3 | 19 | 153.55 | 84.43 | 2.232 | 2.506 | 53.12 | 104.17 | 0.772 | 0.867 |
| 4 | 25 | 199.20 | 113.92 | 2.518 | 2.653 | 58.93 | 111.11 | 0.745 | 0.785 |
| 5 | 19 | 138.61 | 109.76 | 1.941 | 2.277 | 39.84 | 84.11 | 0.988 | 1.159 |
| 6 | 19 | 162.68 | 94.94 | 2.324 | 2.615 | 58.93 | 79.72 | 0.842 | 0.947 |
| 7 | 18 | 128.65 | 111.11 | 1.835 | 2.018 | 60.59 | 111.94 | 0.864 | 0.950 |
| 8 | 28 | 156.04 | 107.14 | 2.453 | 2.838 | 59.76 | 97.83 | 0.939 | 1.087 |
| 9 | 25 | 151.89 | 116.13 | 1.839 | 2.543 | 58.1 | 112.65 | 0.703 | 0.973 |
| 10 | 22 | 152.72 | 120.64 | 1.322 | 1.824 | 74.7 | 126.76 | 0.647 | 0.892 |
| 11 | 18 | 137.78 | 130.81 | 1.658 | 1.942 | 56.44 | 136.36 | 0.679 | 0.795 |
| Group II | | | | | | | | | |
| 1 | 23 | 161.02 | 87.89 | 2.258 | 2.468 | 54.78 | 93.75 | 0.768 | 0.840 |
| 2 | 18 | 157.00 | 83.03 | 2.122 | 2.442 | 54.78 | 77.45 | 0.740 | 0.852 |
| 3 | 20 | 146.00 | 120.00 | 1.976 | 2.292 | 53.12 | 83.64 | 0.719 | 0.834 |
| 4 | 20 | 169.32 | 152.03 | 2.365 | 2.747 | 74.70 | 149.01 | 1.043 | 1.212 |
| 5 | 24 | 159.36 | 120.00 | 2.452 | 2.495 | 47.31 | 120.00 | 0.728 | 0.741 |
| 6 | 21 | 144.40 | 121.62 | 1.781 | 2.031 | 70.55 | 80.72 | 0.870 | 0.992 |
| 7 | 19 | 149.40 | 98.36 | 2.052 | 2.201 | 56.44 | 114.65 | 0.775 | 0.992 |
| 8 | 18 | 132.80 | 90.36 | 1.889 | 2.147 | 35.69 | 93.75 | 0.508 | 0.577 |
| 9 | 28 | 136.00 | 105.88 | 1.535 | 1.832 | 68.89 | 105.14 | 0.778 | 0.928 |
| Group III | | | | | | | | | |
| 1 | 28 | 172.64 | 129.50 | 2.222 | 2.763 | 63.08 | 114.65 | 0.812 | 1.010 |
| 2 | 19 | 130.30 | 102.04 | 1.856 | 2.088 | 45.65 | 69.77 | 0.650 | 0.732 |
| 3 | 23 | 181.77 | 108.43 | 2.313 | 2.536 | 53.95 | 107.78 | 0.686 | 0.757 |
| 4 | 28 | 121.18 | 94.74 | 1.700 | 1.848 | 42.33 | 89.55 | 0.594 | 0.645 |

Table 5. (Continued)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Group III | | | | | | | | | |
| 5 | 25 | 151.89 | 115.68 | 2.502 | 2.961 | 55.61 | 101.81 | 0.916 | 1.084 |
| 6 | 20 | 196.71 | 116.28 | 2.223 | 2.776 | 53.95 | 83.33 | 0.610 | 0.761 |
| 7 | 21 | 153.55 | 126.76 | 1.912 | 2.190 | 38.18 | 133.14 | 0.475 | 0.544 |
| 8 | 18 | 120.35 | 138.46 | 2.271 | 2.653 | 31.54 | 119.36 | 0.595 | 0.695 |
| 9 | 28 | 183.43 | 92.21 | 1.829 | 2.089 | 92.96 | 89.64 | 0.927 | 1.057 |
| Group IV | | | | | | | | | |
| 1 | 25 | 168.49 | 125.35 | 2.861 | 3.302 | 56.44 | 107.66 | 0.958 | 1.106 |
| 2 | 25 | 147.74 | 110.02 | 2.291 | 2.444 | 48.14 | 112.5 | 0.746 | 0.796 |
| 3 | 20 | 137.78 | 110.02 | 1.960 | 2.110 | 55.61 | 93.17 | 0.791 | 0.852 |
| 4 | 25 | 163.51 | 86.04 | 2.174 | 2.457 | 57.27 | 98.68 | 0.762 | 0.861 |
| 5 | 18 | 151.06 | 96.15 | 2.285 | 2.425 | 40.67 | 132.35 | 0.615 | 0.653 |
| 6 | 18 | 120.35 | 109.75 | 1.615 | 1.839 | 57.27 | 91.84 | 0.769 | 0.875 |
| 7 | 22 | 116.20 | 112.5 | 2.530 | 2.993 | 23.24 | 95.95 | 0.505 | 0.599 |
| 8 | 28 | 107.90 | 105.14 | 1.735 | 2.045 | 43.99 | 91.84 | 0.707 | 0.834 |
| 9 | 23 | 144.42 | 125.00 | 1.908 | 2.337 | 49.80 | 100.56 | 0.658 | 0.806 |
| 10 | 21 | 157.70 | 101.12 | 1.949 | 2.070 | 58.10 | 112.5 | 0.718 | 0.763 |
| 11 | 21 | 128.65 | 120.64 | 2.285 | 2.688 | 16.6 | 131.58 | 0.295 | 0.347 |

Table 6. Mid-test I Raw Data Pertaining to Back and Abdominal Variables

| Subject Number | Age (Years) | Isom. Max. Back Strength | Isom. Max. Back St. Heart Rate | Isom. Max. Back St. per kg of Body Weight | Isom. Max. Back St. per kg of Lean Body Weight | Isom. Max. Abdom. St. | Isom. Max. Abdom. St. Heart Rate | Isom. Max. Abdom. St. per kg of Body Weight | Isom. Max. Abdom. St. per kg of Lean Body Weight |
|---|---|---|---|---|---|---|---|---|---|
| Group I | | | | | | | | | |
| 1 | 24 | 124.5 | 107.14 | 1.726 | 1.925 | 45.65 | 118.42 | 0.633 | 0.706 |
| 2 | 25 | 174.3 | 87.83 | 2.131 | 2.534 | 48.14 | 97.83 | 0.589 | 0.700 |
| 3 | 19 | 166.0 | 71.43 | 2.395 | 2.625 | 57.27 | 109.76 | 0.826 | 0.906 |
| 4 | 25 | 164.34 | 88.24 | 2.080 | 2.195 | 51.46 | 91.84 | 0.651 | 0.687 |
| 5 | 19 | 156.04 | 86.54 | 2.155 | 2.532 | 42.33 | 72.58 | 0.585 | 0.687 |
| 6 | 19 | 163.51 | 86.54 | 2.359 | 2.740 | 58.93 | 93.75 | 0.843 | 0.988 |
| 7 | 18 | 163.51 | 118.42 | 2.384 | 2.536 | 63.91 | 118.56 | 0.932 | 0.991 |
| 8 | 28 | 141.1 | 75.0 | 2.226 | 2.493 | 54.78 | 84.91 | 0.864 | 0.968 |
| 9 | 25 | 161.02 | 115.38 | 1.839 | 2.543 | 49.8 | 104.65 | 0.703 | 0.973 |
| 10 | 22 | 192.56 | 97.83 | 1.679 | 2.203 | 56.44 | 104.65 | 0.492 | 0.646 |
| 11 | 18 | 132.8 | 112.5 | 1.604 | 1.975 | 47.31 | 121.31 | 0.571 | 0.703 |
| Group II | | | | | | | | | |
| 1 | 23 | 159.36 | 102.27 | 2.022 | 2.203 | 53.95 | 115.38 | 0.685 | 0.746 |
| 2 | 18 | 153.55 | 95.74 | 2.056 | 2.350 | 53.95 | 71.46 | 0.723 | 0.827 |
| 3 | 20 | 149.21 | 109.76 | 1.963 | 2.219 | 49.8 | 118.42 | 0.654 | 0.740 |
| 4 | 20 | 165.17 | 91.84 | 2.320 | 2.670 | 72.73 | 149.01 | 1.021 | 1.176 |
| 5 | 24 | 146.91 | 118.42 | 1.948 | 2.083 | 49.8 | 104.65 | 0.660 | 0.706 |
| 6 | 21 | 172.64 | 100.00 | 1.906 | 2.230 | 68.89 | 107.14 | 0.760 | 0.890 |
| 7 | 19 | 128.65 | 83.33 | 1.711 | 1.842 | 48.14 | 66.18 | 0.640 | 0.689 |
| 8 | 18 | 121.18 | 91.84 | 1.712 | 1.992 | 37.35 | 100.00 | 0.530 | 0.616 |
| 9 | 28 | 167.66 | 104.65 | 1.888 | 2.236 | 63.91 | 115.38 | 0.720 | 0.852 |
| Group III | | | | | | | | | |
| 1 | 28 | 174.3 | 104.65 | 2.232 | 2.720 | 65.57 | 104.65 | 0.812 | 1.010 |
| 2 | 19 | 124.5 | 75.0 | 1.727 | 1.890 | 48.97 | 118.42 | 0.679 | 0.745 |
| 3 | 23 | 166.0 | 86.54 | 2.153 | 2.206 | 56.44 | 107.14 | 0.732 | 0.750 |
| 4 | 28 | 132.8 | 91.84 | 1.892 | 2.127 | 48.14 | 86.54 | 0.686 | 0.771 |

Table 6. (Continued)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Group III** | | | | | | | | | |
| 5 | 25 | 166.0 | 95.76 | 2.721 | 3.375 | 64.74 | 125.00 | 1.061 | 1.316 |
| 6 | 20 | 189.24 | 91.84 | 2.158 | 2.627 | 56.44 | 73.77 | 0.644 | 0.783 |
| 7 | 21 | 141.1 | 118.42 | 1.717 | 1.976 | 60.59 | 107.14 | 0.737 | 0.848 |
| 8 | 18 | 120.87 | 121.57 | 2.294 | 2.596 | 34.96 | 122.03 | 0.663 | 0.751 |
| 9 | 28 | 201.69 | 86.54 | 1.973 | 2.281 | 72.21 | 80.36 | 0.707 | 0.817 |
| **Group IV** | | | | | | | | | |
| 1 | 25 | 159.36 | 91.84 | 2.728 | 3.072 | 39.84 | 104.65 | 0.671 | 0.768 |
| 2 | 25 | 123.67 | 109.76 | 1.911 | 2.133 | 44.82 | 97.83 | 0.693 | 0.733 |
| 3 | 20 | 138.61 | 97.83 | 1.939 | 2.233 | 58.1 | 107.14 | 0.813 | 0.935 |
| 4 | 25 | 173.47 | 86.54 | 3.351 | 2.622 | 50.63 | 90.0 | 0.686 | 0.765 |
| 5 | 18 | 132.80 | 118.42 | 1.994 | 2.107 | 44.82 | 115.38 | 0.673 | 0.711 |
| 6 | 18 | 124.50 | 115.38 | 1.901 | 2.060 | 53.12 | 118.42 | 0.815 | 0.879 |
| 7 | 22 | 84.66 | 88.2 | 1.978 | 2.209 | 27.39 | 91.84 | 0.640 | 0.715 |
| 8 | 28 | 117.03 | 86.54 | 1.858 | 2.174 | 44.82 | 78.95 | 0.712 | 0.833 |
| 9 | 23 | 153.55 | 125.0 | 2.031 | 2.487 | 49.8 | 109.76 | 0.659 | 0.807 |
| 10 | 21 | 156.87 | 91.84 | 1.937 | 2.092 | 70.55 | 95.74 | 0.871 | 0.941 |
| 11 | 21 | 101.26 | 107.14 | 1.798 | 2.196 | 29.05 | 132.35 | 0.513 | 0.830 |

Table 7. Mid-test II Raw Data Pertaining to Back and Abdominal Variables

| Subject Number | Age (Years) | Isom. Max. Back Strength | Isom. Max. Back St. Heart Rate | Isom. Max. Back St. per kg of Body Weight | Isom. Max. Back St. per kg of Lean Body Weight | Isom. Max. Abdom. St. | Isom. Max. Abdom. St. Heart Rate | Isom. Max. Abdom. St. per kg of Body Weight | Isom. Max. Abdom. St. per kg of Lean Body Weight |
|---|---|---|---|---|---|---|---|---|---|
| Group I | | | | | | | | | |
| 1 | 24 | 186.75 | 115.38 | 2.576 | 2.920 | 67.23 | 104.65 | 0.927 | 1.051 |
| 2 | 25 | 199.20 | 100.00 | 2.490 | 2.975 | 77.19 | 91.84 | 0.965 | 1.15[illegible] |
| 3 | 19 | 204.18 | 68.18 | 2.968 | 3.336 | 58.10 | 84.91 | 0.844 | 0.949 |
| 4 | 25 | 250.66 | 86.54 | 3.153 | 3.322 | 72.21 | 104.65 | 0.908 | 0.957 |
| 5 | 19 | 178.45 | 95.74 | 2.568 | 2.975 | 49.81 | 78.95 | 0.717 | 0.830 |
| 6 | 19 | 182.60 | 93.75 | 2.612 | 3.076 | 64.74 | 90.00 | 0.926 | 1.091 |
| 7 | 18 | 174.30 | 107.14 | 2.512 | 2.716 | 68.06 | 103.81 | 0.931 | 1.061 |
| 8 | 28 | 164.34 | 65.22 | 2.568 | 2.876 | 48.14 | 78.98 | 0.750 | 0.842 |
| 9 | 25 | 197.50 | 112.82 | 2.302 | 3.077 | 66.40 | 109.76 | 0.774 | 1.034 |
| 10 | 22 | 258.13 | 109.76 | 2.239 | 2.919 | 87.15 | [illegible].42 | 0.756 | 0.985 |
| 11 | 18 | 175.13 | 91.84 | 2.138 | 2.576 | 58.10 | 107.14 | 0.709 | 0.855 |
| Group II | | | | | | | | | |
| 1 | 23 | 186.75 | 86.53 | 2.340 | 2.674 | 64.74 | 70.31 | 0.811 | 0.927 |
| 2 | 18 | 184.26 | 93.75 | 2.500 | 2.874 | 56.44 | 62.50 | 0.765 | 0.923 |
| 3 | 20 | 161.85 | 118.42 | 2.164 | 2.532 | 74.70 | 107.14 | 0.999 | 1.169 |
| 4 | 20 | 226.59 | 115.38 | 3.160 | 3.627 | 85.49 | 132.35 | 1.192 | 1.368 |
| 5 | 24 | 207.50 | 121.62 | 2.759 | 2.972 | 62.25 | 86.54 | 0.828 | 0.891 |
| 6 | 21 | 200.86 | 100.00 | 2.270 | 2.588 | 74.70 | 93.75 | 0.840 | 0.963 |
| 7 | 19 | 189.24 | 86.54 | 2.497 | 2.773 | 58.10 | 86.54 | 0.766 | 0.851 |
| 8 | 18 | 158.52 | 93.08 | 2.236 | 2.630 | 47.19 | 92.30 | 0.666 | 0.783 |
| 9 | 28 | 183.43 | 93.75 | 2.043 | 2.478 | 66.40 | 88.24 | 0.739 | 0.897 |
| Group III | | | | | | | | | |
| 1 | 28 | 258.96 | 104.65 | 3.282 | 4.070 | 72.21 | 107.14 | 0.925 | 1.135 |
| 2 | 19 | 188.41 | 80.36 | 2.679 | 3.144 | 57.27 | 91.84 | 0.815 | 0.956 |
| 3 | 23 | 220.78 | 104.65 | 2.834 | 2.850 | 58.10 | 97.83 | 0.746 | 0.750 |

Table 7. (Continued)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Group III** | | | | | | | | | |
| 4 | 28 | 163.50 | 92.88 | 2.293 | 2.579 | 55.57 | 88.38 | 0.779 | 0.876 |
| 5 | 25 | 187.58 | 93.75 | 3.080 | 4.289 | 60.59 | 93.75 | 0.995 | 1.385 |
| 6 | 20 | 262.28 | 86.54 | 2.944 | 3.661 | 58.10 | 86.54 | 0.652 | 0.811 |
| 7 | 21 | 200.86 | 102.27 | 2.45[illegible] | 2.771 | 73.04 | 107.14 | 0.893 | 1.008 |
| 8 | 18 | 141.10 | 118.42 | 2.613 | 3.084 | 31.54 | 115.38 | [illegible] | 0.689 |
| 9 | 28 | 247.34 | 93.75 | 2.449 | 2.775 | 109.56 | [illegible] | 1.085 | 1.229 |
| **Group IV** | | | | | | | | | |
| 1 | 25 | 211.65 | 90.00 | 3.569 | 4.282 | 52.29 | 93.75 | 0.882 | [illegible] |
| 2 | 25 | 141.10 | 115.38 | 2.188 | 2.357 | 58.10 | 109.75 | 0.901 | 0.971 |
| 3 | 20 | 153.55 | 90.00 | 2.206 | 2.560 | 55.61 | 83.33 | 0.927 | 0.927 |
| 4 | 25 | 225.76 | 102.27 | 3.114 | 3.535 | 70.55 | 115.38 | 0.973 | 1.105 |
| 5 | 18 | 186.76 | 112.50 | 2.783 | 2.902 | 58.10 | 107.14 | 0.866 | 0.903 |
| 6 | 18 | 141.93 | 107.14 | 1.890 | 2.131 | 58.10 | 115.38 | 0.774 | 0.873 |
| 7 | 22 | 122.84 | 95.74 | 2.830 | 3.291 | 26.56 | 95.74 | 0.612 | 0.711 |
| 8 | 28 | 127.82 | 84.91 | 2.013 | 2.379 | 45.65 | 94.74 | 0.719 | 0.850 |
| 9 | 23 | 202.52 | 115.38 | 2.700 | 3.221 | 60.59 | 102.27 | 0.808 | 0.964 |
| 10 | 21 | 190.07 | 76.27 | 2.358 | 2.581 | 80.51 | 100.00 | 0.999 | 1.093 |
| 11 | 21 | 126.99 | 97.83 | 2.244 | 2.475 | 37.35 | 95.74 | 0.660 | 0.728 |

Table 8. Post-test Raw Data Pertaining to Back and Abdominal Variables

| Subject Number | Age (Years) | Isom. Max. Back Strength | Isom. Max. Back St. Heart Rate | Isom. Max. Back St. per kg of Body Weight | Isom. Max. Back St. per kg of Lean Body Weight | Isom. Max. Abdom. St. | Isom. Max. Abdom. St. Heart Rate | Isom. Max. Abdom. St. per kg of Body Weight | Isom. Max. Abdom. St. per kg of Lean Body Weight |
|---|---|---|---|---|---|---|---|---|---|
| Group I | | | | | | | | | |
| 1 | 24 | 246.51 | 128.57 | 3.424 | 3.966 | 77.19 | 121.62 | 1.072 | 1.242 |
| 2 | 25 | 218.29 | 104.65 | 2.656 | 3.109 | 78.62 | 95.74 | 0.949 | 1.110 |
| 3 | 19 | 215.82 | 71.92 | 3.138 | 3.540 | 65.24 | 86.32 | 0.948 | 1.070 |
| 4 | 25 | 228.25 | 91.84 | 2.900 | 3.106 | 70.55 | 95.74 | 0.896 | 0.960 |
| 5 | 19 | 190.9 | 112.54 | 2.783 | 3.411 | 58.10 | 90.00 | 0.847 | 1.038 |
| 6 | 19 | 180.11 | 66.18 | 2.592 | 2.973 | 74.70 | 83.33 | 1.075 | 1.233 |
| 7 | 18 | 199.26 | 78.95 | 2.870 | 3.074 | 74.70 | 107.14 | 1.076 | 1.153 |
| 8 | 28 | 199.20 | 86.54 | 3.157 | 3.108 | 73.04 | 93.75 | 1.157 | 1.139 |
| 9 | 25 | 188.00 | 121.62 | 2.184 | 2.930 | 74.70 | 118.42 | 0.868 | 1.164 |
| 10 | 22 | 240.64 | 97.86 | 2.131 | 2.[illegible]4 | 85.49 | 86.54 | 0.757 | 1.000 |
| 11 | 18 | 193.39 | 93.75 | 2.322 | 2.785 | 63.91 | 86.54 | 0.767 | 0.920 |
| Group II | | | | | | | | | |
| 1 | 23 | 239.04 | 95.74 | 3.076 | 3.429 | 68.89 | 86.54 | 0.887 | 0.988 |
| 2 | 18 | 194.82 | 92.47 | 2.633 | 2.979 | 60.35 | 66.38 | 0.816 | 0.923 |
| 3 | 20 | 192.56 | 118.42 | 2.561 | 2.905 | 68.81 | 118.42 | 0.916 | 1.039 |
| 4 | 20 | 238.29 | 115.38 | 3.160 | 3.627 | 83.00 | 121.62 | 1.192 | 1.368 |
| 5 | 24 | 178.45 | 118.42 | 2.759 | 2.972 | 59.76 | 112.50 | 0.828 | 0.891 |
| 6 | 21 | 209.49 | 95.74 | 2.373 | 2.698 | 85.49 | 109.76 | 0.966 | 1.098 |
| 7 | 19 | 175.13 | 86.54 | 2.332 | 2.543 | 70.55 | 91.84 | 0.939 | 1.025 |
| 8 | 18 | 169.08 | 91.80 | 2.388 | 2.762 | 51.10 | 102.24 | 0.722 | 0.835 |
| 9 | 28 | 196.71 | 104.65 | 2.215 | 2.630 | 77.19 | 93.75 | 0.876 | 1.043 |
| Group III | | | | | | | | | |
| 1 | 28 | 262.00 | 102.27 | 3.346 | 4.156 | 74.70 | 107.14 | 0.954 | 1.185 |
| 2 | 19 | 199.54 | 104.65 | 2.775 | 3.170 | 44.82 | 97.83 | 0.623 | 0.712 |
| 3 | 23 | 211.65 | 118.42 | 2.696 | 2.725 | 72.21 | 118.42 | 0.920 | 0.930 |
| 4 | 28 | 166.83 | 86.54 | 2.324 | 2.564 | 56.44 | 88.23 | 0.786 | 0.868 |

Table 8. (Continued)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Group III | | | | | | | | | | |
| 5 | 25 | 226.59 | 91.84 | 3.715 | 4.402 | 56.44 | 84.91 | 0.825 | 1.096 |
| 6 | 20 | 268.92 | 91.84 | 2.971 | 3.669 | 74.70 | 91.84 | 0.825 | 1.019 |
| 7 | 21 | 228.25 | 118.42 | 2.727 | 3.116 | 72.21 | 118.42 | 0.863 | 0.986 |
| 8 | 18 | 156.87 | 118.42 | 2.878 | 3.297 | 50.80 | 107.14 | 0.932 | 1.068 |
| 9 | 28 | 229.08 | 64.29 | 2.286 | 2.646 | 101.26 | 84.91 | 1.093 | 1.266 |
| Group IV | | | | | | | | | |
| 1 | 25 | 195.05 | 115.38 | 3.224 | 3.574 | 44.82 | 136.36 | 0.741 | 0.821 |
| 2 | 25 | 165.17 | 109.77 | 2.530 | 2.765 | 56.44 | 107.14 | 0.866 | 0.945 |
| 3 | 20 | 164.34 | 104.65 | 2.382 | 2.722 | 63.91 | 102.27 | 0.926 | 1.058 |
| 4 | 25 | 229.91 | 104.65 | 3.708 | 3.877 | 68.06 | 121.62 | 1.100 | 1.148 |
| 5 | 18 | 178.45 | 121.62 | 2.644 | 2.798 | [illegible] | 125.00 | 0.861 | 0.911 |
| 6 | 18 | 157.70 | 104.65 | 2.094 | 2.326 | 62.25 | 118.42 | 0.827 | 0.918 |
| 7 | 22 | 105.41 | 107.14 | 2.412 | 2.814 | 34.03 | 112.50 | 0.779 | 0.908 |
| 8 | 28 | 161.02 | 86.53 | 2.481 | 2.981 | 48.97 | 105.91 | 0.755 | 0.907 |
| 9 | 23 | 207.50 | 93.75 | 2.767 | 3.340 | 60.59 | 95.74 | 0.808 | 0.964 |
| 10 | 21 | 199.20 | 93.75 | 2.409 | 2.600 | 77.19 | 115.38 | 0.933 | 1.007 |
| 11 | 21 | 124.50 | 63.38 | 2.247 | 2.635 | 45.65 | 95.74 | 0.824 | 0.966 |

Table 9. Pre-test Raw Data on Vertical Jump, Isotonic Concentric, Isokinetic Concentric, and Isokinetic Eccentric Maximum Strength Heart Rates

| Subject Number | Age (Years) | Isot. Max. Con. Leg Strength Heart Rate | Isok. Max. Conc. Leg Strength Heart Rate | Isok. Max. Ecc. Leg Strength Heart Rate (bpm) | Vertical Jump (cm) |
|---|---|---|---|---|---|
| Group I | | | | | |
| 1 | 24 | 136.36 | 114.50 | 142.86 | 47.5 |
| 2 | 25 | 90.00 | 101.12 | 101.12 | 48.5 |
| 3 | 19 | 111.50 | 114.50 | 106.38 | 55.5 |
| 4 | 25 | 130.43 | 120.00 | 97.30 | 66.5 |
| 5 | 19 | 115.38 | 125.35 | 141.07 | 54.5 |
| 6 | 19 | 109.76 | 82.95 | 79.65 | 45.5 |
| 7 | 18 | 107.14 | 129.68 | 115.98 | 52.5 |
| 8 | 28 | 118.42 | 105.88 | 100.00 | 52.0 |
| 9 | 25 | 157.89 | 136.33 | 124.55 | 39.5 |
| 10 | 22 | 130.43 | 114.80 | 115.98 | 37.5 |
| 11 | 18 | 132.35 | 123.97 | 113.06 | 49.0 |
| Group II | | | | | |
| 1 | 23 | 126.76 | 109.76 | 86.54 | 42.0 |
| 2 | 18 | 157.89 | 102.27 | 86.04 | 53.8 |
| 3 | 20 | 140.86 | 92.02 | 113.21 | 54.0 |
| 4 | 20 | 145.16 | 135.14 | 145.63 | 56.0 |
| 5 | 24 | 100.00 | 69.98 | 122.62 | 49.0 |
| 6 | 21 | 140.63 | 115.38 | 118.11 | 56.0 |
| 7 | 19 | 125.51 | 112.50 | 86.54 | 49.0 |
| 8 | 18 | 105.88 | 103.45 | 111.11 | 49.0 |
| 9 | 28 | 125.00 | 101.01 | 117.19 | 36.0 |
| Group III | | | | | |
| 1 | 28 | 132.00 | 132.35 | 125.00 | 50.8 |
| 2 | 19 | 77.58 | 115.68 | 110.84 | 56.2 |

Table 9. (Continued)

| | | | | | |
|---|---|---|---|---|---|
| **Group III** | | | | | |
| 3 | 23 | 115.38 | 108.17 | 97.65 | 60.0 |
| 4 | 28 | 96.77 | 118.11 | 115.38 | 46.0 |
| 5 | 25 | 112.50 | 83.96 | 106.38 | 53.0 |
| 6 | 20 | 97.83 | 95.74 | 104.65 | 47.5 |
| 7 | 21 | 112.50 | 115.09 | 136.36 | 57.0 |
| 8 | 18 | 125.0 | 134.42 | 132.35 | 57.0 |
| 9 | 28 | 91.87 | 99.78 | 103.45 | 67.0 |
| **Group IV** | | | | | |
| 1 | 25 | 104.65 | 123.97 | 149.50 | 44.8 |
| 2 | 25 | 134.33 | 114.50 | 127.84 | 50.0 |
| 3 | 20 | 109.76 | 104.90 | 137.35 | 50.0 |
| 4 | 25 | 115.38 | 97.61 | 94.54 | 50.3 |
| 5 | 18 | 115.38 | 113.55 | 103.69 | 53.5 |
| 6 | 18 | 112.50 | 142.86 | 122.62 | 45.0 |
| 7 | 22 | 115.38 | 105.63 | 110.29 | 52.5 |
| 8 | 29 | 90.91 | 84.43 | 92.40 | 43.5 |
| 9 | 23 | 134.33 | 121.62 | 120.81 | 52.0 |
| 10 | 21 | 111.11 | 95.74 | 87.38 | 55.0 |
| 11 | 21 | 130.43 | 102.74 | 136.78 | 50.0 |

Table 10. Mid-test I Raw Data on Vertical Jump, Isotonic Concentric, Isokinetic Concentric, and Isokinetic Eccentric Maximum Strength Heart Rates

| Subject Number | Age (Years) | Isot. Max. Con. Leg. Strength Heart Rate | Isok. Max. Conc. Leg. Strength Heart Rate | Isok. Max. Ecc. Leg Strength Heart Rate (bpm) | Vertical Jump (cm) |
|---|---|---|---|---|---|
| Group I | | | | | |
| 1 | 24 | 112.5 | 110.5 | 138.31 | 50.7 |
| 2 | 25 | 90.0 | 86.54 | 93.75 | 50.5 |
| 3 | 19 | 107.14 | 109.76 | 107.14 | 57.5 |
| 4 | 25 | 104.65 | 107.14 | 100.00 | 61.0 |
| 5 | 19 | 93.75 | 93.75 | 43.75 | 44.5 |
| 6 | 19 | 93.75 | 97.83 | 100.00 | 50.5 |
| 7 | 18 | 95.74 | 88.24 | 84.91 | 58.0 |
| 8 | 28 | 115.38 | 91.84 | 102.27 | 53.0 |
| 9 | 25 | 133.00 | 132.35 | 120.00 | 44.0 |
| 10 | 22 | 107.14 | 132.75 | 132.35 | 38.0 |
| 11 | 18 | 115.38 | 132.35 | 115.38 | 43.5 |
| Group II | | | | | |
| 1 | 23 | 118.42 | 95.74 | 81.82 | 43.5 |
| 2 | 18 | 88.24 | 115.33 | 100.00 | 52.5 |
| 3 | 20 | 107.14 | 109.76 | 155.17 | 57.0 |
| 4 | 20 | 126.79 | 145.86 | 142.53 | 59.5 |
| 5 | 24 | 107.14 | 88.24 | 97.83 | 52.0 |
| 6 | 21 | 115.38 | 111.11 | 107.14 | 58.0 |
| 7 | 19 | 107.14 | 102.27 | 70.31 | 50.5 |
| 8 | 18 | 107.14 | 107.14 | 78.26 | 52.5 |
| 9 | 28 | 125.0 | 132.35 | 102.27 | 43.0 |
| Group III | | | | | |
| 1 | 28 | 111.11 | 118.42 | 97.83 | 55.0 |
| 2 | 19 | 107.14 | 97.83 | 100.00 | 61.5 |

Table 10. (Continued)

| | | | | | |
|---|---|---|---|---|---|
| Group III | | | | | |
| 3 | 23 | 140.0 | 118.42 | 107.14 | 67.0 |
| 4 | 28 | 93.75 | 88.24 | 78.95 | 47.0 |
| 5 | 25 | 120.63 | 140.63 | 78.95 | 51.0 |
| 6 | 20 | 105.96 | 109.76 | 91.84 | 51.0 |
| 7 | 21 | 115.38 | 140.63 | 109.76 | 61.8 |
| 8 | 18 | 140.63 | 140.63 | 97.83 | 52.5 |
| 9 | 28 | 100.00 | 104.65 | 109.76 | 64.5 |
| Group IV | | | | | |
| 1 | 25 | 104.58 | 90.0 | 125.0 | 59.0 |
| 2 | 25 | 134.33 | 136.36 | 118.42 | 50.0 |
| 3 | 20 | 109.69 | 115.38 | 118.42 | 48.5 |
| 4 | 25 | 136.36 | 97.83 | 95.74 | 50.0 |
| 5 | 18 | 107.14 | 107.14 | 118.42 | 53.0 |
| 6 | 18 | 107.14 | 104.65 | 125.0 | 44.0 |
| 7 | 22 | 107.14 | 97.83 | 107.14 | 55.3 |
| 8 | 28 | 81.08 | 84.91 | 78.95 | 41.0 |
| 9 | 23 | 134.26 | 112.5 | 134.33 | 54.5 |
| 10 | 21 | 113.92 | 94.74 | 100.00 | 54.0 |
| 11 | 21 | 115.38 | 95.74 | 86.54 | 55.0 |

Table 11. Mid-test II Raw Data on Vertical Jump, Isotonic Concentric, Isokinetic Concentric, and Isokinetic Eccentric Maximum Strength Heart Rates

| Subject Number | Age (Years) | Isot. Max. Con. Leg Strength Heart Rate | Isok. Max. Conc. Leg Strength Heart Rate | Isok. Max. Ecc. Leg Strength Heart Rate (Bpm) | Vertical Jump (cm) |
|---|---|---|---|---|---|
| Group I | | | | | |
| 1 | 24 | 121.62 | 140.63 | 136.36 | 47.0 |
| 2 | 25 | 107.14 | 118.42 | 140.63 | 50.5 |
| 3 | 19 | 114.00 | 100.00 | 100.00 | 55.5 |
| 4 | 25 | 91.84 | 104.65 | 97.83 | 64.5 |
| 5 | 19 | 95.74 | 86.54 | 115.38 | 49.0 |
| 6 | 19 | 104.65 | 102.27 | 100.00 | 57.5 |
| 7 | 18 | 102.60 | 121.62 | 100.00 | 58.0 |
| 8 | 28 | 115.38 | 91.84 | 93.75 | 54.0 |
| 9 | 25 | 109.76 | 104.65 | 93.75 | 41.5 |
| 10 | 22 | 125.00 | 150.00 | 125.00 | 40.0 |
| 11 | 18 | 136.36 | 95.74 | 115.38 | 48.0 |
| Group II | | | | | |
| 1 | 23 | 115.38 | 91.52 | 125.00 | 50.0 |
| 2 | 18 | 97.61 | 107.14 | 107.14 | 57.0 |
| 3 | 20 | 145.16 | 127.58 | 136.36 | 61.5 |
| 4 | 20 | 136.16 | 141.64 | 140.63 | 65.7 |
| 5 | 24 | 109.76 | 118.42 | 121.62 | 51.0 |
| 6 | 21 | 115.38 | 104.15 | 103.45 | 61.0 |
| 7 | 19 | 118.42 | 88.24 | 77.59 | 52.0 |
| 8 | 18 | 116.51 | 102.92 | 83.97 | 55.2 |
| 9 | 28 | 132.35 | 118.42 | 107.14 | 43.0 |
| Group III | | | | | |
| 1 | 28 | 118.42 | 107.14 | 136.36 | 56.5 |
| 2 | 19 | 114.85 | 112.50 | 109.76 | 61.0 |

Table 11 (Continued)

| | | | | | |
|---|---|---|---|---|---|
| Group III | | | | | |
| 3 | 23 | 125.00 | 150.00 | 115.38 | 65.5 |
| 4 | 28 | 102.27 | 109.38 | 104.65 | 47.5 |
| 5 | 25 | 127.63 | 136.36 | 125.00 | 55.0 |
| 6 | 20 | 112.50 | 93.75 | 104.65 | 50.5 |
| 7 | 21 | 138.46 | 104.65 | 102.2[illegible] | 61.0 |
| 8 | 18 | 155.29 | 107.14 | 132.35 | 53.0 |
| 9 | 28 | 107.71 | 102.27 | 104.65 | 67.5 |
| Group IV | | | | | |
| 1 | 25 | 109.76 | 93.75 | 107.14 | 54.0 |
| 2 | 25 | 125.00 | 125.00 | 121.14 | 49.3 |
| 3 | 20 | 121.62 | 103.45 | 97.83 | 50.0 |
| 4 | 25 | 126.36 | 107.14 | 80.36 | 53.0 |
| 5 | 18 | 91.84 | 97.83 | 86.54 | 55.0 |
| 6 | 18 | 97.24 | 112.50 | 118.42 | 53.0 |
| 7 | 22 | 90.00 | 115.38 | 104.65 | 56.5 |
| 8 | 28 | 84.91 | 107.14 | 97.83 | 56.5 |
| 9 | 23 | 88.24 | 118.42 | 118.42 | 58.5 |
| 10 | 21 | 91.84 | 109.76 | 102.27 | 54.5 |
| 11 | 21 | 115.38 | 102.27 | 107.14 | 58.5 |

Table 12. Post-test Raw Data on Vertical Jump, Isotonic Concentric, Isokinetic Concentric, and Isokinetic Eccentric Maximum Strength Heart Rates

| Subject Number | Age (Years) | Isot. Max. Con. Leg Strength Heart Rate | Isok. Max. Conc. Leg. Strength Heart Rate | Isok. Max. Ecc. Leg Strength Heart Rate (bpm) | Vertical Jump (cm) |
|---|---|---|---|---|---|
| Group I | | | | | |
| 1 | 24 | 93.75 | 145.16 | 145.16 | 45.7 |
| 2 | 25 | 93.75 | 107.14 | 107.14 | 50.0 |
| 3 | 19 | 102.44 | 96.99 | 92.75 | 55.5 |
| 4 | 25 | 109.76 | 84.91 | 93.75 | 67.5 |
| 5 | 19 | 140.63 | 86.54 | 108.13 | 47.0 |
| 6 | 19 | 93.09 | 86.54 | 83.33 | 49.0 |
| 7 | 18 | 91.04 | 115.38 | 93.75 | 53.5 |
| 8 | 28 | 118.38 | 102.27 | 90.00 | 52.5 |
| 9 | 25 | 118.42 | 125.00 | 112.50 | 42.0 |
| 10 | 22 | 113.44 | 140.63 | 107.14 | 40.0 |
| 11 | 18 | 125.00 | 95.74 | 104.65 | 47.5 |
| Group II | | | | | |
| 1 | 23 | 112.06 | 107.14 | 97.83 | 48.5 |
| 2 | 18 | 94.29 | 100.94 | 112.47 | 55.4 |
| 3 | 20 | 150.00 | 100.00 | 155.17 | 59.5 |
| 4 | 20 | 140.63 | 160.71 | 140.63 | 61.0 |
| 5 | 24 | 118.42 | 84.91 | 132.35 | 52.7 |
| 6 | 21 | 109.76 | 118.14 | 145.16 | 60.5 |
| 7 | 19 | 104.65 | 77.59 | 68.18 | 51.5 |
| 8 | 18 | 113.19 | 96.72 | 89.30 | 53.6 |
| 9 | 18 | 121.62 | 145.16 | 109.76 | 39.3 |
| Group III | | | | | |
| 1 | 28 | 140.63 | 118.42 | 104.65 | 54.0 |
| 2 | 19 | 93.75 | 115.38 | 107.14 | 60.0 |

Table 12. (Continued)

| | | | | | |
|---|---|---|---|---|---|
| Group III | | | | | |
| 3 | 23 | 116.99 | 118.42 | 140.63 | 70.5 |
| 4 | 28 | 115.38 | 91.84 | 76.27 | 48.0 |
| 5 | 25 | 129.99 | 91.84 | 91.84 | 51.5 |
| 6 | 20 | 104.65 | 107.14 | 104.65 | 51.0 |
| 7 | 21 | 140.60 | 118.42 | 125.00 | 61.5 |
| 8 | 18 | 136.36 | 121.62 | 128.00 | 53.8 |
| 9 | 28 | 100.00 | 115.38 | 95.74 | 67.0 |
| Group IV | | | | | |
| 1 | 25 | 112.50 | 90.0 | 90.0 | 56.8 |
| 2 | 25 | 125.[illegible] | 109.76 | 109.76 | 51.0 |
| 3 | 20 | 115.38 | 107.14 | 107.14 | 50.5 |
| 4 | 25 | 131.11 | 91.84 | 91.84 | 52.4 |
| 5 | 18 | 102.27 | 91.84 | 91.84 | 60.0 |
| 6 | 18 | 90.0 | 115.38 | 115.38 | 53.5 |
| 7 | 22 | 112.50 | 115.38 | 115.38 | 56.5 |
| 8 | 28 | 76.27 | 91.84 | 92.84 | 38.5 |
| 9 | 23 | 107.14 | 93.75 | 93.75 | 54.0 |
| 10 | 21 | 104.65 | 98.25 | 98.25 | 53.0 |
| 11 | 21 | 115.38 | 104.65 | 104.65 | 55.0 |

Table 13. Pre-test Raw Data Pertaining to Body Composition

| Subject Number | Age (Years) | Body Weight (kg) | Percentage of Body Fat | Lean Body Weight (kg) | Vital Capacity | Chart Reading (Unit Range 75) | Water Density |
|---|---|---|---|---|---|---|---|
| Group I | | | | | | | |
| 1 | 24 | 71.0 | 14.[illegible]3 | 60.75 | 5.[illegible] | 50.10 | .99455 |
| 2 | 25 | 79.2 | 16.12 | 66.44 | 5.25 | 58.0 | .99455 |
| 3 | 19 | 68.8 | 10.95 | 61.27 | 5.52 | 55.9 | .99455 |
| 4 | 25 | 79.1 | 5.08 | 75.08 | 6.7 | 58.0 | .99455 |
| 5 | 19 | 71.4 | 14.75 | 60.87 | 4.71 | 4.59 | .99455 |
| 6 | 19 | 70.0 | 11.14 | 62.2 | 4.59 | 67.1 | .99455 |
| 7 | 18 | 70.1 | 9.04 | 63.76 | 5.18 | 63.2 | .99455 |
| 8 | 28 | 63.6 | 13.58 | 54.96 | 3.52 | 72.2 | .99455 |
| 9 | 25 | 82.6 | 27.67 | 59.74 | 4.95 | 45.1 | .99455 |
| 10 | 22 | 115.5 | 27.53 | 83.71 | 5.43 | 51.0 | .99455 |
| 11 | 18 | 83.1 | 14.62 | 70.95 | 4.63 | 69.75 | .9944 |
| Group II | | | | | | | |
| 1 | 23 | 71.3 | 8.49 | 65.25 | 5.03 | 66.5 | .99455 |
| 2 | 18 | 74.0 | 13.14 | 64.28 | 5.35 | 58.25 | .9944 |
| 3 | 20 | 73.9 | 13.81 | 63.7 | 5.32 | 57.5 | .99455 |
| 4 | 20 | 71.6 | 13.93 | 61.63 | 4.05 | 70.5 | .99455 |
| 5 | 24 | 65.0 | 1.72 | 63.88 | 5.63 | 63.6 | .99455 |
| 6 | 21 | 81.0 | 12.35 | 71.07 | 5.59 | 61.0 | .99455 |
| 7 | 19 | 72.8 | 6.74 | 67.89 | 5.09 | 69.3 | .99455 |
| 8 | 18 | 70.3 | 12.03 | 61.25 | 4.17 | 70.9 | .99455 |
| 9 | 18 | 88.6 | 16.19 | 74.25 | 5.19 | 63.8 | .99455 |
| Group III | | | | | | | |
| 1 | 28 | 77.7 | 19.59 | 62.48 | 5.32 | 51.2 | .99455 |
| 2 | 19 | 70.2 | 11.13 | 62.39 | 4.61 | 67.0 | .99455 |
| 3 | 23 | 78.6 | 8.79 | 71.69 | 5.57 | 65.0 | .99455 |
| 4 | 28 | 71.3 | 80.3 | 65.58 | 5.19 | 65.3 | .99455 |
| 5 | 25 | 60.7 | 15.49 | 51.3 | 4.78 | 53.8 | .99455 |

Table 13. (Continued)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Group III | | | | | | | |
| 6 | 20 | 88.5 | 19.92 | 70.87 | 4.94 | 60.3 | .99455 |
| 7 | 21 | 80.3 | 12.68 | 70.12 | 4.41 | 73.5 | .99455 |
| 8 | 18 | 53.0 | 14.39 | 45.37 | 2.60 | 75.5 | .99455 |
| 9 | 28 | 100.3 | 12.29 | 87.97 | 6.72 | 60.25 | .99455 |
| Group IV | | | | | | | |
| 1 | 25 | 58.9 | 13.36 | 51.03 | 2.63 | 79.8 | .99455 |
| 2 | 25 | 64.5 | 6.29 | 60.45 | 4.16 | 74.4 | .99455 |
| 3 | 20 | 70.3 | 7.11 | 65.3 | 4.58 | 72.8 | .99455 |
| 4 | 25 | 75.2 | 11.5 | 66.55 | 4.63 | 69.5 | .99455 |
| 5 | 18 | 66.1 | 5.75 | 62.3 | 5.5 | 61.0 | .9944 |
| 6 | 18 | 74.5 | 12.14 | 65.45 | 4.31 | 71.8 | .99455 |
| 7 | 22 | 46.0 | 15.59 | 38.83 | 3.02 | 65.5 | .99455 |
| 8 | 28 | 62.2 | 15.16 | 52.77 | 4.60 | 57.1 | .99455 |
| 9 | 23 | 75.5 | 18.36 | 61.8 | 4.08 | 66.2 | .99455 |
| 10 | 21 | 80.9 | 5.82 | 76.19 | 5.43 | 72.8 | .99455 |
| 11 | 21 | 56.3 | 14.99 | 47.86 | 3.01 | 72.1 | .99455 |

Table 14. Mid-test I Raw Data Pertaining to Body Composition

| Subject Number | Age (Years) | Body Weight (kg) | Percentage of Body Fat | Lean Body Weight (kg) | Vital Capacity | Chart Reading (Unit Range 75) | Water Density |
|---|---|---|---|---|---|---|---|
| Group I | | | | | | | |
| 1 | 24 | 72.1 | 10.31 | 60.75 | 5.82 | 55.6 | .9944 |
| 2 | 25 | 81.8 | 15.91 | 68.79 | 5.23 | 60.1 | .9944 |
| 3 | 19 | 69.3 | 8.75 | 63.23 | 5.6 | 58.3 | .9944 |
| 4 | 25 | 79.0 | 5.22 | 74.88 | 6.3 | 62.3 | .99455 |
| 5 | 19 | 72.4 | 14.88 | 61.63 | 4.78 | 61.3 | .99455 |
| 6 | 19 | 69.3 | 13.88 | 59.68 | 4.58 | 63.2 | .9944 |
| 7 | 18 | 68.6 | 6.02 | 64.47 | 5.32 | 64.6 | .9944 |
| 8 | 28 | 63.4 | 10.74 | 56.59 | 3.52 | 75.6 | .9944 |
| 9 | 25 | 83.2 | 28.69 | 59.33 | 5.14 | 41.5 | .99455 |
| 10 | 22 | 114.7 | 24.12 | 87.40 | 5.94 | 52.5 | .9944 |
| 11 | 18 | 82.8 | 18.78 | 67.25 | 4.63 | 63.0 | .9944 |
| Group II | | | | | | | |
| 1 | 23 | 78.8 | 8.21 | 72.33 | 5.09 | 71.6 | .9944 |
| 2 | 18 | 74.6 | 12.57 | 65.22 | 5.30 | 60.0 | .9944 |
| 3 | 20 | 76.1 | 11.55 | 67.33 | 5.48 | 60.3 | .99455 |
| 4 | 20 | 71.2 | 13.13 | 61.85 | 4.28 | 68.8 | .9944 |
| 5 | 24 | 75.4 | 6.47 | 70.52 | 5.98 | 61.5 | .9944 |
| 6 | 21 | 90.6 | 14.53 | 77.6 | 6.0 | 58.5 | .99455 |
| 7 | 19 | 75.2 | 7.13 | 69.83 | 5.12 | 70.25 | .9944 |
| 8 | 18 | 70.8 | 14.07 | 60.84 | 4.13 | 69.0 | .9944 |
| 9 | 18 | 88.8 | 15.56 | 74.99 | 5.32 | 63.5 | .99455 |
| Group III | | | | | | | |
| 1 | 28 | 78.1 | 17.96 | 64.07 | 5.0 | 57.5 | .99455 |
| 2 | 19 | 72.1 | 8.81 | 65.74 | 4.56 | 72.1 | .9944 |
| 3 | 23 | 77.1 | 2.39 | 75.25 | 6.3 | 65.1 | .9944 |
| 4 | 28 | 70.2 | 11.05 | 62.45 | 5.02 | 62.5 | .9944 |
| 5 | 25 | 61.0 | 19.36 | 49.19 | 4.39 | 54.0 | .9944 |

Table 14. (Continued)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Group III** | | | | | | | |
| 6 | 20 | 87.7 | 17.86 | 72.04 | 5.30 | 59.25 | .99455 |
| 7 | 21 | 82.2 | 13.11 | 71.42 | 4.35 | 74.8 | .9944 |
| 8 | 18 | 52.7 | 11.65 | 46.56 | 2.77 | 76.2 | .9944 |
| 9 | 28 | 102.2 | 13.47 | 88.43 | 6.7 | 59.5 | .9944 |
| **Group IV** | | | | | | | |
| 1 | 25 | 59.4 | 12.67 | 51.87 | 2.62 | 81.0 | .99455 |
| 2 | 25 | 64.7 | 10.37 | 57.99 | 4.01 | 71.3 | .9944 |
| 3 | 20 | 71.5 | 13.18 | 62.08 | 4.36 | 68.0 | .9944 |
| 4 | 25 | 73.8 | 10.36 | 66.16 | 5.18 | 64.0 | .9944 |
| 5 | 18 | 66.6 | 5.38 | 63.02 | 5.55 | 61.2 | .99455 |
| 6 | 18 | 65.2 | 7.29 | 60.45 | 4.61 | 68.6 | .9944 |
| 7 | 22 | 42.8 | 10.47 | 38.32 | 3.1 | 67.0 | .9944 |
| 8 | 28 | 63.0 | 14.57 | 53.82 | 4.58 | 58.5 | .99455 |
| 9 | 23 | 75.6 | 18.34 | 61.74 | 4.14 | 65.5 | .99455 |
| 10 | 21 | 81.0 | 7.43 | 74.98 | 5.48 | 69.8 | .99544 |
| 11 | 21 | 56.6 | 9.37 | 51.3 | 2.64 | 72.7 | .99455 |

Table 15. Mid-test II Raw Data Pertaining to Body Composition

| Subject Number | Age (Years) | Body Weight (kg) | Percentage of Body Far | Lean Body Weight (kg) | Vital Capacity | Chart Reading (Unit Range 75) | Water Density |
|---|---|---|---|---|---|---|---|
| Group I | | | | | | | |
| 1 | 24 | 72.5 | 11[illegible] | 63.96 | 5.84 | 53.6 | .9944 |
| 2 | 25 | 80.0 | 16.3[illegible] | 66.96 | 5.43 | 56.4 | .9941 |
| 3 | 19 | 68.8 | 11.04 | 61.2 | 5.41 | 57.2 | .99425 |
| 4 | 25 | 79.5 | 5.09 | 75.45 | 6.42 | 61.6 | .9944 |
| 5 | 19 | 69.5 | 13.68 | 59.99 | 4.98 | 59.0 | .9944 |
| 6 | 19 | 69.9 | 15.07 | 59.36 | 4.62 | 61.8 | .9939 |
| 7 | 18 | 69.4 | 7.54 | 64.17 | 5.22 | 64.5 | .9941 |
| 8 | 28 | 64.0 | 10.71 | 57.15 | 3.58 | 75.5 | .9941 |
| 9 | 25 | 85.8 | 25.18 | 64.19 | 5.35 | 46.0 | .9941 |
| 10 | 22 | 115.3 | 23.3 | 88.4 | 5.90 | 55.3 | .9941 |
| 11 | 18 | 81.9 | 17.0 | 67.98 | 4.58 | 66.0 | .99245 |
| Group II | | | | | | | |
| 1 | 23 | 79.1 | 11.71 | 69.84 | | | |
| 2 | 18 | 73.7 | 13.03 | 64.1 | 5.3 | 58.8 | .9944 |
| 3 | 20 | 74.8 | 14.56 | 63.91 | 5.02 | 60.5 | .9944 |
| 4 | 20 | 71.7 | 12.86 | 62.48 | 4.25 | 70.0 | .9944 |
| 5 | 24 | 75.2 | 7.14 | 69.83 | 6.04 | 59.8 | .99425 |
| 6 | 21 | 88.9 | 12.67 | 77.60 | 6.25 | 58.0 | .99425 |
| 7 | 19 | 75.8 | 9.95 | 68.25 | 5.05 | 67.5 | .99425 |
| 8 | 18 | 70.9 | 14.98 | 60.28 | | | |
| 9 | 18 | 89.8 | 17.56 | 74.03 | 5.15 | 62.8 | .99425 |
| Group III | | | | | | | |
| 1 | 28 | 78.9 | 19.37 | 63.62 | 5.15 | 54.5 | .9939 |
| 2 | 19 | 70.3 | 14.75 | 59.93 | 4.52 | 63.5 | .9941 |
| 3 | 23 | 77.9 | 0.56 | 77.47 | 6.63 | 64.8 | .99425 |
| 4 | 28 | 71.3 | 11.08 | 63.4 | 4.93 | 64.5 | .9939 |
| 5 | 25 | 60.9 | 28.18 | 43.74 | 5.18 | 34.8 | .9941 |

Table 15. (Continued)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Group III** | | | | | | | |
| 6 | 20 | 89.1 | 19.59 | 71.65 | 5.35 | 56.8 | .9941 |
| 7 | 21 | 81.8 | 11.38 | 72.49 | 4.53 | 75.3 | .99425 |
| 8 | 18 | 54.0 | 15.29 | 45.75 | 2.85 | 72.5 | .9941 |
| 9 | 28 | 101.0 | 11.74 | 89.14 | 7.2 | 56.5 | .99425 |
| **Group IV** | | | | | | | |
| 1 | 25 | 59.3 | 16.64 | 49.43 | 2.39 | 79.3 | .994[illegible] |
| 2 | 25 | 64.5 | 7.19 | 59.86 | 4.33 | 72.74 | .99[illegible] |
| 3 | 20 | 69.6 | 13.82 | 59.99 | 4.61 | 63.2 | .9942[illegible] |
| 4 | 25 | 72.5 | 11.91 | 63.27 | 5.15 | 61.5 | .9941 |
| 5 | 18 | 67.1 | 4.09 | 64.36 | 5.88 | 59.8 | .9939 |
| 6 | 18 | 75.1 | 11.34 | 66.59 | 5.01 | 65.5 | .99425 |
| 7 | 22 | 43.4 | 13.99 | 37.33 | 2.92 | 66.6 | .99425 |
| 8 | 28 | 63.5 | 15.51 | 53.73 | | | |
| 9 | 23 | 75.0 | 16.16 | 62.88 | 4.42 | 65.5 | .9939 |
| 10 | 21 | 80.6 | 8.64 | 73.64 | 5.4 | 69.0 | .9939 |
| 1[illegible] | 21 | 56.6 | 14.71 | 47.25 | 3.21 | 76.2 | .99425 |

Table 16. Post-test Raw Data Pertaining to Body Composition

| Subject Number | Age (Years) | Body Weight (kg) | Percentage of Body Fat | Lean Body Weight (kg) | Vital Capacity | Chart Reading (Unit Range 75) | Water Density |
|---|---|---|---|---|---|---|---|
| Group I | | | | | | | |
| 1 | 24 | 72.0 | 13.66 | 62.16 | 5.75 | 51.9 | .9941 |
| 2 | 25 | 82.2 | 14.48 | 70.30 | 5.62 | 58.2 | .99425 |
| 3 | 19 | 68.8 | 11.34 | 61.00 | | | |
| 4 | 25 | 78.7 | 6.7 | 73.49 | 6.48 | 58.0 | .9942 |
| 5 | 19 | 68.6 | 18.42 | 55.96 | 5.06 | 51.5 | .9941 |
| 6 | 19 | 69.5 | 12.84 | 60.58 | 4.78 | 62.5 | .99425 |
| 7 | 18 | 69.4 | 6.62 | 64.81 | 5.39 | 64.0 | .9937 |
| 8 | 28 | 63.1 | 9.63 | 64.10 | 3.58 | 76.2 | .9939 |
| 9 | 25 | 86.1 | 25.48 | 64.16 | | | |
| 10 | 22 | 112.9 | 24.26 | 85.51 | 5.85 | 53.3 | .99355 |
| 11 | 18 | 83.3 | 16.64 | 69.44 | 4.52 | 68.4 | .9937 |
| Group II | | | | | | | |
| 1 | 23 | 77.7 | 10.27 | 63.72 | 5.37 | 65.0 | .9937 |
| 2 | 18 | 74.0 | 11.58 | 65.4 | | | |
| 3 | 20 | 75.2 | 11.85 | 66.29 | 5.46 | 59.7 | .9942 |
| 4 | 20 | 70.8 | 12.29 | 62.1 | 4.4 | 68.6 | .9939 |
| 5 | 24 | 74.5 | 6.47 | 69.72 | 6.22 | 58.5 | .9937 |
| 6 | 21 | 88.5 | 12.05 | 77.84 | 6.54 | 55.75 | .9939 |
| 7 | 19 | 75.1 | 8.31 | 68.86 | 5.39 | 65.7 | .9939 |
| 8 | 18 | 70.8 | 13.53 | 61.22 | | | |
| 9 | 18 | 88.1 | 15.1 | 74.8 | 5.38 | 63.8 | .9937 |
| Group III | | | | | | | |
| 1 | 28 | 78.3 | 19.49 | 63.04 | 5.25 | 53.0 | .9937 |
| 2 | 19 | 71.9 | 12.46 | 62.94 | 4.65 | 66.0 | .99425 |
| 3 | 23 | 78.5 | 1.07 | 77.66 | 6.49 | 66.5 | .9937 |
| 4 | 28 | 71.8 | 9.38 | 65.06 | 5.05 | 65.5 | .9942 |
| 5 | 25 | 61.0 | 15.6 | 51.18 | 5.15 | 50.1 | .99355 |

Table 16. (Continued)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Group III** | | | | | | | |
| 6 | 20 | 90.5 | 19.01 | 73.3 | 5.38 | 58.3 | .9939 |
| 7 | 21 | 83.7 | 12.48 | 73.25 | 4.6 | 74.0 | .9942 |
| 8 | 18 | 54.5 | 12.70 | 47.58 | 2.89 | 75.2 | .9937 |
| 9 | 28 | 100.2 | 13.59 | 86.58 | 6.7 | 58.3 | .9941 |
| **Group IV** | | | | | | | |
| 1 | 25 | 60.5 | 9.78 | 54.58 | 3.13 | 79.5 | .9939 |
| 2 | 25 | 65.3 | 8.54 | 59.73 | 4.28 | 7.10 | .9942 |
| 3 | 20 | 69.0 | 12.49 | 60.38 | 4.62 | 64.5 | .9942 |
| 4 | 25 | 62.0 | 4.35 | 59.3 | 5.57 | 59.0 | .9939 |
| 5 | 18 | 67.5 | 5.51 | 63.78 | 5.76 | 59.5 | .9942 |
| 6 | 18 | 75.3 | 9.97 | 67.8 | 5.24 | 65.0 | .9942 |
| 7 | 22 | 43.7 | 14.28 | 37.46 | 3.1 | 64.5 | .9942 |
| 8 | 28 | 64.9 | 16.76 | 54.02 | 4.62 | 56.9 | .9937 |
| 9 | 23 | 75.0 | 17.15 | 62.13 | 4.28 | 65.5 | .9942 |
| 10 | 21 | 82.7 | 7.36 | 76.62 | 5.86 | 67.0 | .99425 |
| 11 | 21 | 55.4 | 14.71 | 47.25 | 2.95 | 72.7 | .99425 |