1967

The effect of a supplementary training program on the total body endurance of college wrestlers

John Sacchi

*The University of Montana*

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THE EFFECT OF A SUPPLEMENTARY TRAINING PROGRAM ON THE
TOTAL BODY ENDURANCE OF COLLEGE WRESTLERS

By

John Sacchi Jr.

B.S. Ithaca College, 1966

Presented in partial fulfillment of the requirements for
the degree of

Master of Science

UNIVERSITY OF MONTANA

1967

Approved by:

[Signatures]

Chairman, Board of Examiners

Dean, Graduate School

Date
The author wishes to thank Brian J. Sharkey, Graduate Advisor, for his guidance and counseling during the completion of this paper.

The author also wishes to take this opportunity to express his most sincere appreciation to his loving wife, Joan Marie, and his daughter, Kimberly Ann, whose patience and understanding helped make this thesis a reality.

J.S.J.
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CHAPTER I

THE PROBLEM AND DEFINITIONS
OF THE TERMS USED

I. INTRODUCTION

It is generally understood that wrestling demands the utmost in physical conditioning. The ability to withstand the physiological stresses of the sport requires long arduous training. The importance of endurance in wrestling is quite obvious whenever two opponents are equally matched in skill and determination, the wrestler with the greatest endurance generally wins. Many coaches feel that by utilizing a supplementary training program they can help their athletes obtain a greater degree of endurance than that which can be obtained from wrestling practice alone.

Several theories currently exist as to the type of supplementary program which is most beneficial (1, 19, 34). Articles appear each year in various coaching publications advocating specific programs for increasing the endurance in wrestlers. Most of these articles have one thing in common, that is, the theories are speculations and have little, if any, scientific research to support them. Much of this material is being accepted at face value and the possibility exists that the additional time and effort being
spent on these programs could be more profitable if spent in some other area. This study is intended as a point of departure and will investigate one of these specific programs to determine its effectiveness. It is hoped that more interest and research will follow in this area.

II. THE PROBLEM

Statement of the Problem

The purpose of this study was to (1) investigate the effects of a supplementary endurance building program on the total body endurance of college wrestlers during their competitive season; (2) to determine if an endurance building program combined with regular wrestling is more advantageous for building endurance than wrestling practice alone; (3) to investigate the effects of a supplementary endurance program on the physical fitness level of a group of college students enrolled in a physical education wrestling class.

Importance of the Study

Several studies have shown that significant increases in endurance are brought about as a result of training (2, 23, 30). In a study conducted by Kistler (24) it was noted that cardio-respiratory endurance was more difficult to improve than muscular endurance. This study will attempt to determine whether a conditioned athlete can significantly increase his total body endurance (muscular
and cardio-respiratory) beyond the level obtained from regular participation in wrestling practice and intercollegiate contests by the addition of a program of specific endurance building exercises.

If total body endurance can be increased significantly by supplementation, then such a program could prove valuable to those involved in endurance-type activities such as wrestling. Furthermore, if significant increases are noted among the physical education wrestling class subjects, then the possibility of supplementing physical education wrestling classes could prove to be a worthwhile method of increasing the physical fitness of the students involved.

III. BASIC ASSUMPTIONS

The following assumptions were basic to this study.

1. Any increases in the experimental group's endurance level will be the results of the training program.

2. Increases in total body endurance can be measured reliably by the methods described in Chapter III.

IV. LIMITATIONS OF THE STUDY

The following limitations were evident in this study.
1. The study was limited to 24 male subjects attending the University of Montana. Twelve subjects were members of a physical education wrestling class and 12 were members of the 1967 varsity wrestling team.

2. There was no control over the outside activities of the subjects.

V. DEFINITIONS

The following terms are defined as they were used in this study.

**Total Body Endurance.** The combination of muscular endurance and cardio-respiratory endurance.

**Cardio-respiratory Endurance.** Physiological fitness demonstrated through an adjustment of the heart and respiration to prolonged physical work, such as the ability to continue large muscle activity.

**Muscular Endurance.** The ability of muscle or muscle groups to continue submaximal contractions over a period of time.

**Supplementary Endurance Program.** A program of endurance building exercises which were employed in addition to the regular wrestling routine.

**Eight Count Squat Thrust.** The specific exercise which was selected to be used in the supplementary endurance program. The performer begins from the position of attention.
On the count of one the subject squats placing his hands on the floor shoulders width apart and slightly in front of his knees. On the count of two he extends his legs and trunk rearward. On the counts of three and four he performs a push-up. On the counts five and six he performs another push-up. On the count of seven he returns to the squat position and to the starting position on the count of eight.

Set. Ten repetitions of the eight count squat thrust.

Physical Fitness. The ability to perform and continue to perform activities of a vigorous physical nature.
CHAPTER II

SURVEY OF RELATED LITERATURE

A review of the literature revealed numerous and varied training studies concerned with the development of physical fitness. The training studies have investigated the effects of training on various aspects of fitness on both fit and unfit individuals. For the sake of continuity this review will be presented in three sections. The first section will deal with training effects in general, and the second section will deal with training studies dealing directly with wrestling. The third section will be a review of those publications appearing in periodicals and text books which advocate specific training programs but lack conclusive data to support their theories.

I. GENERAL STUDIES

Karvonen (23) studied the effects of training on the cardiovascular system and found that the advantage of a trained cardiovascular system is obvious in performance requiring maximal or near maximal cardiac output. He noted that the higher the maximal cardiac output of an individual, the greater was his working capacity in strenuous exercise. It was also noted that cardiovascular changes are dependent on the type of training; therefore, in order to develop a
more efficient cardiovascular system it is necessary to train at high pulse rate levels.

Knehr, Dill, and Neufeld (25) studied 14 subjects training at middle distance running three days a week for a period of six months. They found that this training period enabled the subjects to withstand a larger oxygen debt resulting in a mean increase of 60 per cent more work being accomplished. There was also a six to seven per cent increase in the transport of oxygen to the tissues during work which represents a clear-cut gain in the amount of work which can be carried on aerobically. Other changes noted as a result of the training were an increased cardiac output, increased circulation to the working muscles and more favorable conditions for exchange of gases between the capillaries and the muscle cells.

Micheal and Gallon (3) conducted a study on a group of college basketball players. A one minute step test was administered to the group each week beginning with the first week of practice. They noticed that in a period of three weeks there was significant improvement in their performance. At the end of six weeks of basketball practice the improvement was significant at the .01 level.

Bell (4), investigating the effects of a season's training on a group of 20 basketball players and 12 varsity track men, tested them on the 75, 150, and 300 yard run and the Taylor pack test. Significant improvements were noticed.
the most significant being in the times for the 300 yard run. Since the basketball players had no training in how to run, the improvement was believed to be due to an increase in endurance.

Several investigators have studied the effects of a weight training program on selected measures of physical fitness. Nagle and Irwin (31) compared the effects of two types of weight training programs on the cardio-respiratory endurance of a group of 60 college freshmen. Two groups of weight trainers were trained three days a week for eight weeks. One group employed high repetitions and low weights while the other used low repetitions and high weights. These two groups were compared to a class in bait casting and a class in archery. A battery of eight cardio-respiratory measures failed to shown any significant changes between the weight training groups and the other two groups.

Capen (9) compared a group of college sophomores in a weight training class against a group of freshmen in a physical conditioning class. Both groups met twice a week for 11 weeks. Both groups improved slightly but there was no significant difference noted between the groups on measures of muscular endurance or cardio-respiratory endurance. The weight training group was found to be superior in the power classification as measured by the Sargent jump, the standing broad jump, and the eight and 12 pound shot put. The difference was significant at the two per cent
level.

Campbell (8) studied a group of football players, basketball players, and track and field men in an attempt to determine which half of the season produced the most significant gains when employing weight training with their regular training. Group A weight trained and participated in the normal training routine for the specific sport during the first half of the season. Then at mid-season Group A stopped weight training and practiced the sport only. Group B, which had been training for the sport only, began weight training in addition to practicing the sport. The groups were evaluated on a group of tests which included right grip strength, jump and reach, squat thrusts, pull-ups, sit-ups, the 50 yard dash and the 300 yard run. Significant improvements were noted in both groups. The track and field group did not show a significant difference between weight training during the first half of the season as compared with weight training during the second half of their season. The football and basketball groups showed a significant difference at the .01 level favoring the first half of the season. The groups that dropped weight training after the first half of the season showed marked decreases in composite t scores when tested at the end of the season. In view of this the author recommended that weight training be started before the season begins and be continued for the duration of the season.
Chui (10) compared the effects of a systematic weight training program on athletic power. A weight training group was equated with a required physical education class. The groups were compared on the Sargent jump, the standing broad jump, the eight and 12 pound shot put and the 60 yard dash. The weight training group showed significant improvement in all measures while the physical education class failed to show any improvement at all.

Burley and Anderson (7) using a group of 51 high school athletes attempted to study the relationship of power on athletic performance. The athletes were tested, as representatives of their particular sport, on the vertical jump, and included track men, swimmers, basketball players, football players, baseball players and tennis players, boxers and wrestlers. It was found that the track men were superior to the other athletes in the study. The other groups scored in this order: swimmers, basketball players, football players, tennis players, boxers and wrestlers and baseball players. It should be noted that with the exception of the swimmers the top groups were superior in respect to the amount of running specific to that sport. It was concluded that power is specific to certain sports.

It appears that improvements in general fitness can be brought about by any strenuous type of exercise program. The extent of the improvement tends to parallel the nature and extent of the training. Weight training studies tend
to be inconclusive insofar as the benefits derived. Studies have shown that weight training will improve fitness. However, when compared with other types of training programs, such as calisthenics, the only measure in which weight training programs were found to be superior were the power categories. Power was also found to be specific to certain sports.

II. SPECIFIC STUDIES

Taylor (38) trained and coached 10 varsity wrestlers five days a week for two hours a day over an eight-week period and found that they showed significant improvement in tests of muscular and cardiovascular endurance and reduction of some body fat. Taylor also noted the effects of wrestling on a physical education class which met for two one-half hour periods a week for eight weeks. Significant improvements were noted in tests of muscular endurance. Improvements in dynamometrical strength, cardiovascular condition, and body fat were not significant.

Johnson (33) studied the effects of six weeks of wrestling compared to six weeks of weight training on the amount of strength developed in 45 wrestlers and 31 weight trainers. The weight training group exercised three times a week doing presses, curls, squats, neck raises, and hip flexions with weighted boots. The wrestlers practiced five days a week doing normal wrestling drills and maneuvers. At
the end of six weeks it was found that neither group had developed significant grip, elbow flexion or neck extension strength. The two programs were of value, however, in significantly developing leg extension, elbow extension, and hip flexion strength.

Berndt (5) divided 30 high school wrestlers into three matched groups. Group A followed a conditioning program utilizing wrestling maneuvers and similar activities. Group B followed normal wrestling practice and in addition trained daily with sit-ups, push-ups, leg lifts, rope climbing, running in place or mile run or rope skipping, deep knee bends and high bridges. Group C followed normal wrestling practice and in addition followed a daily program of weight training which included military presses, curls, rowing exercises, stiff legged dead lifts, and weighted deep knee bends. After the six-week training period the groups were compared on pre- and post-conditioning scores made on the Roger's Physical Fitness Index test. The results showed that the wrestling-only group did not improve significantly, but that the other two groups did. Both the weight training group and the calisthenics group were superior to the wrestling-only group but were not significantly different from each other.

Pfeffer (32) grouped 14 wrestlers into three experimental groups to study the effects of weight training combined with wrestling on the muscular strength and endurance.
of the forearm flexor muscles. Group A participated in wrestling only. Group B wrestled and participated in weight training for strength. Group C wrestled and participated in weight training for endurance. The weight training groups met three times a week for eight weeks. Group B which was weight training for strength used the curl exercise employing three sets of eight repetitions. Whenever the subject could perform nine repetitions the weight was increased. Group C which was weight training for endurance also used the curl exercise with a constant weight of 40 pounds for the entire eight-week period. This group performed the curl to a rhythm of one every two seconds until exhaustion. The subjects were instructed to attempt to increase the number of repetitions over the previous session. It was found that there was no significant difference in the strength of the forearm flexors which could be attributed to supplementing the wrestling practices with weight training for strength. There was, however, a significant increase in the endurance of the forearm flexors for both the strength and endurance training groups. The gain demonstrated by the weight training for endurance group was significant at the .05 level.

Many of the studies dealing with supplementary training programs have found that they are of some value in increasing fitness measures above that achieved by wrestling alone. Much of this data, however, needs to receive closer
investigation to determine the extent of actual wrestling done in these experimental studies. Little wrestling and much supplementation will tend to sway the results in favor of supplementation and vice versa.

III. NON-SCIENTIFIC PUBLICATIONS

Agocs (1) used the theory of interval training in an attempt to improve the general physical condition of his college squad. He employed the eight count squat thrust using 10 repetitions for six sets. Agocs began by allowing a one minute and 15 second rest interval between sets during the first week, and at the beginning of each successive week he decreased the rest interval by 15 seconds. After three weeks he felt that his team was in excellent condition for its first competition.

Gallagher (17), a former coach of several national collegiate championship teams, believes that a wrestler should always supplement his wrestling with some form of calisthenics, especially those that develop the lateral trunk, abdomen, neck, biceps, and triceps. He feels that chinning should be used to develop the arms and shoulders and that rope skipping or running should be used to develop endurance.

Gutin (19) believes that most of the conditioning is gained during the finishing work-out. He employs a program at the end of the practice sessions that consists
of push-ups with or without a man pick-a-back, leaping from a squat position with or without a man pick-a-back, crab walks, five to 10 second sprints, an isometric grip exercise, and rope climbing. This program is carried on approximately five minutes and can be varied depending on the physical condition of the team. Gutin feels this program can be exceedingly taxing for even the well-conditioned athlete.

Several coaches have reported using the idea of fundamental skill drills as a means of achieving or improving the fitness of their wrestling teams. Hanke (20) reports using a series of continuous movement wrestling drills to perfect wrestling moves while also providing a conditioning effect. The drills are designed to cover every phase of wrestling and the drills are timed. The entire sequence can be made as vigorous and taxing as the coach desires by controlling the pace and duration.

Sparks (37) feels sequence and technique drills are especially valuable for the development of balance, speed, agility, and leverage for the essential wrestling maneuvers. He also feels that strength can be developed by increasing the resistance offered and that endurance can be gained by increasing the vigor and duration of the drills.

Reams (34) feels that calisthenics alone are a waste of time because a wrestler seldom uses his muscles in
wrestling the same way he does in a training-type exercise. The author believes that calisthenics are boring and time-consuming and occupy time which could be used for mastery of wrestling holds and maneuvers. He reports using a 10-minute warm-up consisting of various wrestling situations and maneuvers followed by a 15-minute period of instruction and practice on a new skill. After this, the team spends one and one-half hours in actual wrestling scrimmage. The practice session is concluded with a five-minute drill consisting of 10 bouts of running in place as fast as possible for 10 seconds with a five-second rest interval between bouts.

Brown (6) feels that competition in football or cross country prior to the wrestling season is valuable on the assumption that these sports develop stamina and wind for the wrestler. In the early portion of the season Brown recommends distance running of from three to five miles for bringing a wrestler to a peak of condition in a short period of time. During the season he feels that wrestling is the best conditioner for wrestling and that running should be done only on occasion.

Dratz, Johnson, and McCann (15) report using a "going through the mill" technique which resembles interval training in nature. A wrestler wrestles for two minutes, rests for one-half minute, wrestles a fresh man for another two minutes, rests for one-half minute, wrestles a
third man, and so on, in a continuous series of two-minute bouts until satisfied that the wrestler has reached the level of his endurance. The authors are emphatic proponents of the idea that while a general type of endurance can be developed by nearly any strenuous activity, the fitness for a given sport can be developed only by the specific movements of that particular sport. Therefore, they strongly feel that there is no better activity for wrestling conditioning than wrestling itself. Brouha (22) lends support to this statement by saying that for heavy exercise when an individual is trained for a specific activity, he is more efficient and capable of doing more work of that particular nature than when he performs any other kind of exercise.

The literature is inconclusive but tends to indicate that wrestling coupled with a supplementary activity is more beneficial for increasing physical fitness than wrestling alone. This would appear to hold true for other sports as well as indicated by Campbell's (8) study.

The conclusion to be drawn from the literature is not as simple as it may appear. Much would depend on the kind of wrestling, how much, and under what conditions it is practiced. It is quite possible that in certain situations the physiological limits of the athletes are reached in the regular practice sessions and supplementation would be
unnecessary. Little can be said for or against the various training methods until these factors are considered.
CHAPTER III

METHODS AND PROCEDURES

I. SUBJECTS

Twelve subjects were selected from volunteers in a physical education wrestling class and 12 from volunteers of the 1967 varsity wrestling team at the University of Montana. Each subject was given a number and assigned to either the control or the experimental group of his respective organization by use of a table of random numbers. The subjects were instructed as to the procedures of the study and further to their specific responsibilities in the study.

Grouping of the Subjects

In order that the results of this study might have relevance beyond the realm of varsity wrestling, it was decided to have a control and experimental group for a physical education wrestling class as well as for the varsity wrestling team. Six subjects were randomly assigned from the wrestling team to serve in the experimental group; the remaining six were assigned to the control group. The same procedure was used to assign the wrestling class to groups. The following is a list of the groups and the activities they performed during the five-week training program which lasted from January 23rd through February 24th.
**Class Control.** This group attended a physical education wrestling class which met for approximately 40 minutes a day, three days a week, and engaged in normal wrestling instruction and scrimmage.

**Class Experimental.** This group followed the same procedure as the class control and in addition participated in the supplementary endurance building program.

**Varsity Control.** This group attended varsity wrestling practice two hours a day, five days a week, and participated in wrestling instruction, drills, scrimmages, and matches.

**Varsity Experimental.** This group followed the same procedure as the varsity control and in addition attended the supplementary endurance building program.

The physical characteristics of the subjects are shown in Table I.

II. SELECTIONS OF TESTS

The subjects were pre- and post-tested on a battery of four tests. Two of the tests were designed to measure the fitness of the cardiovascular and respiratory mechanism. One test was designed to measure power and one test was specifically designed to measure muscular endurance. The Astrand-Ryhming nomogram for predicting maximal oxygen intake and the 300 yard run were used to measure the efficiency of the cardio-respiratory mechanism, the vertical jump
was used to measure power and the wall pulley test was used to evaluate muscular endurance.

TABLE I

PHYSICAL CHARACTERISTICS OF THE SUBJECTS

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Weight Pounds</th>
<th>Height Inches</th>
<th>Age Years</th>
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<tr>
<td>R.S.</td>
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<tr>
<td>A.P.</td>
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<tr>
<td>D.M.</td>
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<tr>
<td>T.C.</td>
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<td>71</td>
<td>19</td>
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<td>W.G.</td>
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<td>R.P.</td>
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<td>R.T.</td>
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<td>R.W.</td>
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<td>K.Y.</td>
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<td>R.L.</td>
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<td>R.R.</td>
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<td>70</td>
<td>19</td>
</tr>
<tr>
<td>R.M.</td>
<td>142</td>
<td>65</td>
<td>19</td>
</tr>
<tr>
<td>C.S.</td>
<td>150</td>
<td>68</td>
<td>19</td>
</tr>
<tr>
<td>D.G.</td>
<td>155</td>
<td>69</td>
<td>18</td>
</tr>
<tr>
<td>J.T.</td>
<td>140</td>
<td>68</td>
<td>19</td>
</tr>
<tr>
<td>J.F.</td>
<td>134</td>
<td>66</td>
<td>19</td>
</tr>
<tr>
<td>J.M.</td>
<td>174</td>
<td>73</td>
<td>19</td>
</tr>
<tr>
<td>B.T.</td>
<td>150</td>
<td>68</td>
<td>20</td>
</tr>
<tr>
<td>T.H.</td>
<td>160</td>
<td>68</td>
<td>20</td>
</tr>
</tbody>
</table>

Mean 155.5 69 19
Astrand-Ryhming Step Test for Predicting Maximal Oxygen Intake

A five-minute submaximal step test was used as prescribed by Astrand and Ryhming (3) as a means of predicting the maximal oxygen intake during submaximal work. Maximal oxygen intake is felt to be a reliable means of assessing the capacity for hard physical work (2, 3, 21). However, the procedure involved in obtaining a measurement of maximal oxygen intake is a complex and costly procedure in terms of laboratory equipment and time. It has been successfully shown that the maximal oxygen intake can be predicted with fair accuracy by the Astrand-Ryhming nomogram. Several authorities have found high correlations between the predicted maximal oxygen intake and the measured maximal oxygen intake. Hettinger et al. (21) found the correlation to be significant at the .01 level of confidence. Teraslinna, Ismail, and MacLeod (39), DeVires and Klaif (13), Glassford (18), and Sharkey (35) have all reported finding high correlations between the predicted and the measured tests.

300 Yard Run

Lewis (26) investigated the reliability and validity of several selected runs and found that the second trial of the 300 yard run had a higher correlation with maximal oxygen intake than either the 60, 600 yard, or mile run times. It was also found that the 300 yard run had a test
re-test reliability of .94. Bell (4) conducted a study using a freshmen basketball team and a varsity track team and found that the times on the 300 yard run showed the greatest improvement over their competitive season. Since the basketball players had no training in how to run, the improvement was believed to be due to increased endurance.

**Vertical Jump**

The vertical jump was selected as the most feasible method of measuring power. Power is the rate of doing work: hence, force times distance divided by time equals power. The power generated is dependent on the amount of force applied and the speed with which it is applied. Dudley Sargent (28) stated: "The vertical jump is primarily a test of the ability to develop power in relation to the weight of the individual." McCloy (28) feels that the Sargent-type jump is not the one perfect test, but it is probably the one best test we have for predicting explosive energy (power). Several investigators have used this type of measurement with a high degree of precision as reflected by the high test re-test coefficients (11, 16, 28).

**Wall Pulley**

A phasic wall pulley test was devised to measure the endurance of the elbow extensors. Clarke (12) has suggested procedures for this type of testing; however, some modifications were imposed in order that the test might more
closely approximate the push-up which was part of the training program. It was decided to use an angle of 90 degrees and further to keep the weight constant for all subjects. A weight of 15 and one-quarter pounds was used in a pilot study and was found to produce fatigue in approximately two to three minutes. The first trial was used to familiarize the subjects with the test and the next two trials given on successive days were recorded.

III. EQUIPMENT

The following is a list of equipment which was used in this study.

Radio-Electrocardiograph

The Telemedics RKG 100 Radio-Electrocardiograph system was used to record the heart rate during the submaximal step test prescribed by Astrand and Ryhming (3). The system utilized small disposable electrodes which attached to the subject's skin with mole skin adhesive, a pocket-sized battery-operated transmitter which weighed approximately 10 ounces and was contained in a pouch which attached over the subject's shoulder by a thin strap. Thin electrode wires conducted the signal from the electrodes to the transmitter. A portable desk model radio receiver forwarded the signal to the Burdick EK-2 Direct-Recording Electrocardiograph through an EKG adapter. (See Figure 1.)
The Electrodes. The electrodes were integrated into a small adhesive patch and contained an electrode paste reservoir and a contact snap fastener for attachment of the electrode wires. The electrodes were attached to the skin by a two-inch square piece of mole skin adhesive. The point of attachment was on the right and left fifth rib approximately four to five inches from the mid-line of the sternum. The electrodes were attached over the ribs in order to minimize muscle noise.

The Radio Receiver. The radio receiver was a Telemedics RKG 100 and operated from a 115 volt 60 cycle standard power line. A channel selector enabled the electrocardiograph signal to be fed into the recording instrument through an EKG adapter unit.

The Recording Instrument. The recording instrument used was the Burdick EK-2 Direct-Recording Electrocardiograph. This instrument received the EKG signal and recorded the rate on standard permagraph recording paper.

Chalk Board. A black board 15 inches by four feet was lined in one-inch intervals and mounted on a wall to record the vertical jump distances. The board was mounted so that the lower border was six feet from the floor.

Wall Pulley Apparatus. A wall pulley apparatus with adjustable weight plates was employed in testing the muscular endurance of the elbow extensors. The apparatus was attached directly to the wall and had a single pulley
FIGURE 1.
TELEMEDICS RKG 100 RADIO-ELECTROCARDIOGRAPH SYSTEM AND EKG RECORDER
located five feet up from the floor. A double strand of quarter-inch rope was attached to the weight plates at one end and to the grip handle at the other end. The grip handle was made of metal and shaped like a horseshoe with a wooden insert which the subject grasped when performing the test. (See Figure 2.)

Testing Table. The testing table was made of wood and was approximately eight feet by two feet. It contained an adjustable padded arm rest, an adjustable padded shoulder brace, and an adjustable wooden foot brace. A strap was attached to the testing table to limit the movement of the upper arm of the subject when performing the test. (See Figure 2.)

40 Centimeter Bench. A wooden bench 40 centimeters high by 51 centimeters long by 30 centimeters wide was used for the submaximal step test.

Metronome. A metronome was used to set the cadence during the wall pulley test and the step test. The metronome was set at 90 beats per minute for the step test, resulting in 22.5 steps per minute. During the wall pulley test the cadence was set at 60, resulting in 30 contractions per minute. The metronome was also used to maintain the cadence during the training program. A tape recording of the cadence was used so that it could be amplified above the noise of the activity. The cadence for the training program was set at 64 beats per minute, resulting in eight
FIGURE 2.

TESTING TABLE AND WALL PULLEY APPARATUS
complete repetitions of the eight count squat thrust per minute.

IV. TESTING PROCEDURE AND SCHEDULE

Schedule

The subjects were pre-tested on the 16th, 17th, and 18th of January. On each of the first two days the subjects were administered the wall pulley, vertical jump and the 300 yard run tests. On the third day the subjects were administered the Astrand-Ryhming submaximal step test and the final trial of the wall pulley test. Five subjects were tested per hour by appointment, thus enabling them to receive at least five minutes rest between tests.

The post-test was conducted in the same order as the pre-test on February 27th, 28th, and March 1st.

Procedure

The tests were administered in the following manner.

Wall Pulley. The subject assumed a supine position on the testing table. The right arm was adducted to 180 degrees and the forearm placed in 90 degree flexion and fully pronated. The subject placed his left hand on his chest and his feet against the wooden foot brace. The metronome was set at 60 beats per minute allowing one beat for extension and one for flexion, resulting in 30 contractions per minute. The testor placed the restraining strap
on the subject's upper arm and placed his left hand on the subject's right shoulder to prevent other muscle groups from assisting the movement.

The subject grasped the wall pulley handle and exercised to the cadence by extending the forearm to 180 degrees on one beat and flexing on the alternate beat. The subject was stopped when he was no longer able to maintain the cadence. Exhaustion occurred for most subjects in less than two minutes. The subjects were given one trial per day over the three-day testing period. Trial one served to familiarize the subjects with the test; trials two and three were averaged to produce the subject's score. A reliability correlation of .86 was found between trials two and three.

**Vertical Jump.** The subject was allowed at least five minutes rest before being tested on the vertical jump. All subjects were instructed and given a demonstration in the correct method for performing the vertical jump.

Maximum reach was measured by having the subject place his toes against the wall, heels flat, and extending his arms and fingers in a natural manner over his head on the chalk board. This was recorded as the subject's maximum reach. The subject was given a practice jump and then scored on the average of the following two jumps. The test was administered twice and found to have a reliability correlation of .92 when the measurement was carried to the
nearest quarter inch.

**300 Yard Run.** The 300 yard run was conducted on a 100 yard oval indoor track. Three laps completed the test and the subjects were instructed to run as fast as they could and also to stay close to the rail on the turns. Times were recorded to the nearest half second. Two trials of the 300 yard run were administered on separate days and a reliability correlation of .90 was found between trials one and two.

**Astrand-Ryhming Submaximal Step Test.** The subjects were seated for at least 10 minutes prior to taking the step test. This was to enable their heart rates to reach a resting level. During this time the electrodes were placed on the subjects and the resting heart rate was taken. The subjects were instructed as to the procedures of the step test and shown a demonstration during this time also.

The electrode wires were attached to the subject and the portable transmitter placed around his neck and shoulder. The metronome was set at 90 beats per minute, and the subject began stepping to the cadence as soon as he was given the signal by the tester. The test lasted for five minutes, during which time two 10-second heart rate recordings were taken. One recording was taken during the three minutes and 30 seconds to three minutes and 40 seconds interval and another reading taken from four minutes and 30 seconds to four minutes and 40 seconds. The two recordings
were averaged and this average became the heart rate for that subject. It was decided to use this technique rather than the one suggested by Astrand and Ryhming (3) on the basis of the findings made by Sharkey (35). Sharkey found that in untrained individuals the predicted maximal oxygen intake varied from the measured over 700 ml/kg/min partly because of fluctuations in the heart rate during the last minute of exercise. Since this study contained untrained as well as trained individuals, it was decided that averaging the last two minutes of heart rate would eliminate this variable and produce a more accurate prediction of maximal oxygen consumption.

V. TRAINING PROCEDURE

McCloy postulated that when training for strenuous activity there should be more emphasis on a systematic program of overload for development of muscular and cardiorespiratory endurance (27). This theory was utilized in this study by adding a program of supplementary "overload" exercises to the regular training routine of college wrestlers.

After an investigation of the commonly used types of exercises, the eight count squat thrust was selected as a good calisthenic for building total body endurance. It has been stated by McCloy (29) that push-ups are a test of the endurance of the muscles of the arms and of the shoulder
girdle and that squat thrusts, when performed for at least a minute, may be used as a measure of total body endurance. It was felt that combining the push-up with the squat thrust would result in an excellent form of calisthenics for building total body endurance.

Agocs (1) published an article relating to the eight count squat thrust being used as a supplementary endurance building exercise, and the procedure outlined by him was used in this study. The procedure is as follows. Ten repetitions constituted a set, six sets constituted a day's workout. The rest interval between sets was one and one-half minutes in length for the first week of the program and was reduced by 15 seconds for each successive week of training. The reasoning behind reducing the rest interval receives support from Brouha and Radford (22) who state that as soon as a rest interval becomes too short the heart rate increases during successive periods of both exercise and recovery. The steady state can no longer be maintained; therefore, the individual comes closer and closer to his maximum working capacity and his exhaustion level. By using this theory a coach or athlete achieves progressively strenuous training without an increase in workout time.

The experimental groups met three times a week on Mondays, Wednesdays, and Fridays at a prescribed hour during the school day and participated in the supplementary
endurance program. The training program lasted for five weeks. The training sessions were supervised to insure attendance and proper performance of the exercises.
CHAPTER IV

ANALYSIS AND DISCUSSION OF RESULTS

I. INTRODUCTION

This chapter contains the analysis of the data collected before and after the five-week training period in which the effects of a supplementary endurance building program upon the total body endurance of college wrestlers and a physical education wrestling class were studied. The data which was collected is presented in Tables II-VI, and is discussed in this chapter.

II. ANALYSIS OF RESULTS

It was the purpose of this study to determine the results of a five-week supplementary endurance building program, incorporated with normal wrestling conditioning, upon the total body endurance of college wrestlers and a group of students in a physical education wrestling class. The mean scores for the pre-test and the mean scores for the post-test on a battery of four physical fitness tests were compared and the results appear in Table II.

From the results shown in Table II, the data indicates that maximal oxygen intake was increased to a greater degree by the groups participating in the supplementary
# TABLE II

**MEAN CHANGES AFTER TRAINING**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Test</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Astrand-Ryhming ml/kg body weight</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>C.C.*</td>
<td>48.7</td>
<td>51.0</td>
</tr>
<tr>
<td>C.E.*</td>
<td>50.0</td>
<td>53.5</td>
</tr>
<tr>
<td>V.C.*</td>
<td>53.8</td>
<td>50.0</td>
</tr>
<tr>
<td>V.E.*</td>
<td>51.1</td>
<td>56.7</td>
</tr>
</tbody>
</table>

|        | 300 Yard Run seconds |            |
|        | Pre-test | Post-test |            |
| C.C.   | 46.3     | 44.6      | -1.7       |
| C.E.   | 44.0     | 42.9      | -1.1       |
| V.C.   | 45.9     | 45.0      | 0.1        |
| V.E.   | 45.0     | 45.0      | 0.0        |

|        | Wall Pulley repetitions |            |
|        | Pre-test | Post-test |            |
| C.C.   | 53.3     | 47.6      | -5.7       |
| C.E.   | 50.3     | 53.8      | 3.5        |
| V.C.   | 50.6     | 60.3      | 9.7        |
| V.E.   | 53.4     | 57.3      | 3.9        |

|        | Vertical Jump inches |            |
|        | Pre-test | Post-test |            |
| C.C.   | 21.6     | 22.9      | 1.3        |
| C.E.   | 22.8     | 23.6      | 0.8        |
| V.C.   | 22.7     | 25.6      | 2.9        |
| V.E.   | 20.5     | 20.9      | 0.4        |

*C.C. = Class control; C.E. = Class experimental; V.C. = Varsity control; V.E. = Varsity experimental.*
training program as indicated by the Astrand-Ryhming test. All the groups showed an increase in maximal oxygen intake; however, both experimental groups displayed higher scores than their respective control group.

In the 300 yard run the only significant improvement was made by the wrestling class groups. The class control group showed the greatest amount of improvement, while both the varsity groups failed to make any improvements at all.

The wall pulley test revealed muscular endurance increases for all groups except the class control group which showed a marked decrease from pre-test to post-test. The greatest improvement was made by the varsity control group.

In the vertical jump the greatest improvement was made by the control groups. Both the class and varsity experimental groups failed to show a significant increase from pre-test to post-test.

A two-way analysis of variance was used to test the group means for significant differences. In this type of statistic interaction is used to measure the tendency for the subject performance to vary along with trials: it measures the factors attributable to neither subjects nor trials alone, but rather to both acting together (14). To achieve significance the F-ratio at the .05 level had to be 6.92. The data obtained is presented in Tables III VI.
and preceded by a brief discussion of the results.

**Astrand-Ryhming Test**

In Table II it was noted that with the exception of the varsity control group, all groups showed an increase in their post-test scores. The improvements shown by the wrestling class groups were comparable, but the greatest improvement was made by the varsity experimental group.

From the results shown in Table III, the data indicates that there was no significant difference between the row means and the column means. There was, however, significant interaction at the .05 level. This significant interaction indicates that there was improvement within the groups which cannot be distinguished, that is, there was no one single effect. Instead there were two separate effects: one due to supplementation and one related to the nature of the group. The improvements were not great enough to warrant significance between the various groups. The significant interaction indicated that the combination of wrestling group and treatment resulted in the greatest improvement.

**300 Yard Run**

From the results shown in Table IV, all factors were found to be significant at the .05 level. The significance with which the wrestling class surpassed the
### TABLE III
**ANALYSIS OF VARIANCE FOR ASTRAND-RYHMING TEST**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rows</td>
<td>1</td>
<td>28.37</td>
<td>28.37</td>
<td>2.85</td>
</tr>
<tr>
<td>Columns</td>
<td>1</td>
<td>28.37</td>
<td>28.37</td>
<td>2.85</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>63.37</td>
<td>63.37</td>
<td>6.36*</td>
</tr>
<tr>
<td>Error</td>
<td>92</td>
<td>917.51</td>
<td>9.97</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>211.61</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at .05 level

### TABLE IV
**ANALYSIS OF VARIANCE FOR 300 YARD RUN**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rows</td>
<td>1</td>
<td>4.07</td>
<td>4.07</td>
<td>4.96*</td>
</tr>
<tr>
<td>Columns</td>
<td>1</td>
<td>4.00</td>
<td>4.00</td>
<td>4.88*</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>4.65</td>
<td>4.65</td>
<td>5.67*</td>
</tr>
<tr>
<td>Error</td>
<td>92</td>
<td>75.23</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>62.51</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at the .05 level

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Varsity wrestling groups could account for the significant F-ratios for the rows and columns. The significant interaction effect indicates that there was no one treatment or group that was responsible for the difference. It does indicate, however, that there was a combination of wrestling-only and wrestling with supplementation working together.

**Vertical Jump**

In Table V, significant differences can be noted for both rows and columns as well as for interaction. All the groups improved; however, the very large increase shown by the control groups tends to carry the minor increases of the experimental groups to a .01 level of significance. The significant interaction indicates that there was no one single effect operating but a combination of effects.

**Wall Pulley**

The wall pulley test for muscular endurance was the only test which failed to show any significant differences. The F-ratios for the rows and columns were .44 short of being significant at the .05 level. The interaction was far from approaching significance. The data for the wall pulley test appears in Table VI.
### TABLE V

**ANALYSIS OF VARIANCE FOR VERTICAL JUMP**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Effects</td>
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</tr>
<tr>
<td>Rows</td>
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<td>33.14</td>
<td>107*</td>
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<tr>
<td>Columns</td>
<td>1</td>
<td>33.16</td>
<td>33.16</td>
<td>107*</td>
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<tr>
<td>Interaction</td>
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<td>295*</td>
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<tr>
<td>Error</td>
<td>92</td>
<td>28.89</td>
<td>.31</td>
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<tr>
<td>Total</td>
<td>95</td>
<td>128.93</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at the .01 level

### TABLE VI

**ANALYSIS OF VARIANCE FOR WALL PULLEY**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F-ratio</th>
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</thead>
<tbody>
<tr>
<td>Treatment Effects</td>
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</tr>
<tr>
<td>Rows</td>
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<tr>
<td>Columns</td>
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<td>67.36</td>
<td>67.36</td>
<td>3.51</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>25.60</td>
<td>25.60</td>
<td>1.56</td>
</tr>
<tr>
<td>Error</td>
<td>92</td>
<td>1764.79</td>
<td>19.18</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>160.32</td>
<td></td>
<td></td>
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</table>
III. DISCUSSION OF RESULTS

The results of this study indicate that participation in wrestling as a sport and as a physical education activity will bring about significant increases in physical fitness. Post-test differences were noted in the area of maximal oxygen intake, cardio-respiratory endurance, power and muscular endurance. The data indicates that in individual cases muscular endurance was improved; however, when the data was subjected to a statistical analysis, it was found to lack significance at the .05 level.

Improvements in the maximal oxygen intake post-test means were evident in all groups except the varsity control which showed a marked decrease. Both experimental groups had higher post-test scores than either control group. Subject R.T., a member of the varsity control group, was experiencing an upper respiratory infection at the time of the post-test which appeared to hamper his performance and tended to lower the group mean.

Cardio-respiratory endurance was increased in both the control and experimental groups of the physical education wrestling class, as evidenced by the post-test means for the Astrand-Ryhming test and the 300 yard run. The results of the two cardio-respiratory tests were not in agreement. The Astrand-Ryhming test showed post-test improvements favoring the varsity experimental group while
the 300 yard run post-test scores clearly indicated improvements by the wrestling class groups and none whatsoever for the varsity groups. Conflicting results such as these cast doubt on the acceptability of these tests as adequate measures of physical fitness for wrestling.

Increases in muscular endurance were evident in all groups except the wrestling class control group which showed a marked decrease from pre-test to post-test. The greatest increase in muscular endurance was made by the varsity control group. Subject R.L., a member of this group, increased his post-test score by 18 repetitions which tended to elevate the group mean. Without R.L.'s score, the post-test mean for the varsity control group would still be the highest as each member except one showed marked increases from pre-test to post-test.

The post-test means for the vertical jump showed a sizable improvement for both control groups, while both experimental groups displayed only minor increases.

When the data was subjected to a two-way analysis of variance to determine the effects of the training program on the groups, the improvements were found to be insignificantly different in many cases. Muscular endurance was not significantly different, nor was there any evidence of interaction. There was no significant difference on the Astrand-Ryhming test of predicted maximal oxygen intake; however, there was significant interaction at the .05 level.
which would tend to indicate that there was considerable improvement among individual subjects. The significant interaction effect would indicate that a combination of treatment effect and groups were necessary to achieve significant difference results. There were significant differences shown in the 300 yard run test of cardio-respiratory endurance between and within the groups and for interaction at the .05 level of confidence. There was no obvious difference between the control and the experimental groups, indicating that wrestling-only is as beneficial as wrestling with supplementation for building cardio-respiratory endurance as measured by the 300 yard run. The interaction indicated that improvement was made as a result of treatment effects and groups in combination and no single variable was significant. In the vertical jump there were significant differences between and within the groups and for interaction at the .01 level, indicating that wrestling significantly increases power. The interaction indicated that two separate effects caused the significance; therefore, wrestling with supplementation failed to increase power above that attained from wrestling-only.

From the results of this study it would appear that wrestling alone is as beneficial for building total body endurance as wrestling with a supplementary endurance building program of eight count squat thrusts. This finding is in direct disagreement with the proposal set forth
by Agocs (1) who felt that after three weeks of training with the eight count squat thrust the physical conditioning of his wrestling team was greatly improved. The results further tend to disagree with the theory of Gallagher (17) and the findings of Brendt (5), and tend to support the ideas of Sparks (37), Hanke (20), Reams (34), and Dratz, Johnson, and McCann (15). Furthermore, it appears that the current practice of supplementing the physical education activity of wrestling with endurance building calisthenics may be reduced and more time spent on the practicing of the activity itself.

From the results of this study it appears that the endurance derived from participating in an activity such as wrestling is as great as that derived from supplementing that activity with a specific program of endurance building calisthenics.
CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY

It was the purpose of this study to investigate the effects of a five-week supplementary endurance building program on the total body endurance of a group of college wrestlers and a group of students taking wrestling as a physical education activity. Twelve college wrestlers were randomly assigned to serve in either the control group or the experimental group of the varsity wrestling team. Twelve volunteers from a physical education wrestling class were similarly assigned to a control or experimental group for the wrestling class. The subjects were pre-tested on a battery of four physical fitness tests designed to measure maximal oxygen intake, cardio-respiratory endurance, muscular endurance, and power.

Following the pre-test the experimental groups underwent five weeks of supplementary endurance training in addition to their regular wrestling regime. Upon completion of the five weeks of supplementary endurance training, all of the subjects were administered the post-test to determine the results of the training program. A two-way analysis of variance was employed to determine the effects
of the training on the various groups. The results of this test indicate that significant differences in improvement scores were made as a result of participation in a wrestling program with or without supplementation on measures of cardio-respiratory endurance and power. No significant differences in improvement were noticed in respect to the muscular endurance of the elbow extensors. The data further indicated that no difference existed between the groups which participated in wrestling alone and the groups which participated in wrestling with a supplementary eight count thrust program as noted by the significant F-ratios for interaction on the Astrand-Ryhming, 300 yard run, and vertical jump.

II. CONCLUSIONS

The following conclusions were made on the basis of the findings in this study.

1. There were no significant differences noted in the muscular endurance of the forearm extensors in either the control or experimental groups.

2. Significant interactions were noted for cardio-respiratory endurance as measured by the Astrand-Ryhming test of predicted maximal oxygen intake and the 300 yard run.

3. A significant interaction effect was noted in
power as measured by the vertical jump test.

4. There were no clearly significant differences between the wrestling-only groups and the wrestling with supplementation groups in regards to increases in cardio-respiratory endurance, muscular endurance, or power.

III. RECOMMENDATIONS

In view of the results of this study it is recommended that:

1. Training schema be subjected to careful analysis before they receive widespread publicity.

2. Current curricular practices of supplementing regular physical education activity programs with fitness exercises should receive scrutiny.
BIBLIOGRAPHY


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37. Sparks, R. E. "Conditioning for Effective Wrestling," 

38. Taylor, A. W. "A study of the Fitness Effects of 
    Varsity Wrestling and Required Wrestling Training Program." Master's Thesis, University of 
    British Columbia. Abstracted from *Completed Research in Health and Physical Education* 1965; 
    7:41, Washington, D.C.

39. Teraslinna, P., A. H. Ismail and D. F. MacLeod. 
    "Nomogram by Astrand–Ryhming as a Predictor of 
APPENDIX A

ASTRAND-RYHMING SCORES BEFORE AND AFTER TRAINING

<table>
<thead>
<tr>
<th>Subject</th>
<th>Pre-test (ml/kg body weight)</th>
<th>Post-test (ml/kg body weight)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.S.</td>
<td>50</td>
<td>57</td>
<td>7</td>
</tr>
<tr>
<td>R.M.</td>
<td>57</td>
<td>51</td>
<td>-6</td>
</tr>
<tr>
<td>R.R.</td>
<td>46</td>
<td>55</td>
<td>9</td>
</tr>
<tr>
<td>R.A.</td>
<td>55</td>
<td>56</td>
<td>1</td>
</tr>
<tr>
<td>R.M.</td>
<td>39</td>
<td>42</td>
<td>3</td>
</tr>
<tr>
<td>C.M.</td>
<td>45</td>
<td>45</td>
<td>0</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td><strong>48.7</strong></td>
<td><strong>51</strong></td>
<td><strong>2.3</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subject</th>
<th>Pre-test (ml/kg body weight)</th>
<th>Post-test (ml/kg body weight)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.H.</td>
<td>64</td>
<td>69</td>
<td>5</td>
</tr>
<tr>
<td>D.G.</td>
<td>36</td>
<td>48</td>
<td>12</td>
</tr>
<tr>
<td>J.T.</td>
<td>30</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>B.T.</td>
<td>56</td>
<td>60</td>
<td>4</td>
</tr>
<tr>
<td>J.F.</td>
<td>54</td>
<td>55</td>
<td>1</td>
</tr>
<tr>
<td>J.M.</td>
<td>60</td>
<td>49</td>
<td>-11</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td><strong>50</strong></td>
<td><strong>53.5</strong></td>
<td><strong>3.5</strong></td>
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</tbody>
</table>

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### APPENDIX A (Cont'd.)

#### Varsity Control

<table>
<thead>
<tr>
<th>Subject</th>
<th>Pre-test (ml/kg body weight)</th>
<th>Post-test (ml/kg body weight)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.T.</td>
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<td>62</td>
<td>-14</td>
</tr>
<tr>
<td>R.W.</td>
<td>44</td>
<td>47</td>
<td>3</td>
</tr>
<tr>
<td>K.Y.</td>
<td>62</td>
<td>51</td>
<td>-11</td>
</tr>
<tr>
<td>D.R.</td>
<td>44</td>
<td>42</td>
<td>-2</td>
</tr>
<tr>
<td>G.W.</td>
<td>39</td>
<td>44</td>
<td>5</td>
</tr>
<tr>
<td>R.L.</td>
<td>58</td>
<td>54</td>
<td>-4</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td><strong>53.8</strong></td>
<td><strong>50</strong></td>
<td><strong>-3.8</strong></td>
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#### Varsity Experimental

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<th>Subject</th>
<th>Pre-test (ml/kg body weight)</th>
<th>Post-test (ml/kg body weight)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>W.G.</td>
<td>49</td>
<td>52</td>
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<tr>
<td>R.P.</td>
<td>50</td>
<td>56</td>
<td>6</td>
</tr>
<tr>
<td>A.P.</td>
<td>46</td>
<td>51</td>
<td>5</td>
</tr>
<tr>
<td>T.C.</td>
<td>57</td>
<td>59</td>
<td>2</td>
</tr>
<tr>
<td>D.M.</td>
<td>50</td>
<td>58</td>
<td>8</td>
</tr>
<tr>
<td>R.S.</td>
<td>55</td>
<td>58</td>
<td>3</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td><strong>51.1</strong></td>
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<td><strong>5.6</strong></td>
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### APPENDIX B

#### 300 YARD RUN SCORES BEFORE AND AFTER TRAINING

<table>
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<th>Subject</th>
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<th>Post-test (Seconds)</th>
<th>Difference</th>
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</thead>
<tbody>
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<tr>
<td>R.M.</td>
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<td>45.3</td>
<td>-1.0</td>
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<td>R.R.</td>
<td>44.5</td>
<td>43.5</td>
<td>-1.0</td>
</tr>
<tr>
<td>R.A.</td>
<td>44.3</td>
<td>43.0</td>
<td>-1.3</td>
</tr>
<tr>
<td>R.M.</td>
<td>48.5</td>
<td>43.3</td>
<td>-5.3</td>
</tr>
<tr>
<td>C.M.</td>
<td>48.3</td>
<td>47.5</td>
<td>-0.8</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td><strong>46.3</strong></td>
<td><strong>44.6</strong></td>
<td><strong>-1.7</strong></td>
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</tbody>
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<table>
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<tr>
<th>Subject</th>
<th>Pre-test (Seconds)</th>
<th>Post-test (Seconds)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.H.</td>
<td>42.0</td>
<td>40.5</td>
<td>-1.5</td>
</tr>
<tr>
<td>D.G.</td>
<td>47.3</td>
<td>47.8</td>
<td>0.5</td>
</tr>
<tr>
<td>J.T.</td>
<td>46.5</td>
<td>45.0</td>
<td>-1.5</td>
</tr>
<tr>
<td>B.T.</td>
<td>44.0</td>
<td>42.5</td>
<td>-1.5</td>
</tr>
<tr>
<td>J.F.</td>
<td>41.8</td>
<td>40.0</td>
<td>-1.8</td>
</tr>
<tr>
<td>J.M.</td>
<td>42.5</td>
<td>41.8</td>
<td>-0.7</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td><strong>44.0</strong></td>
<td><strong>42.9</strong></td>
<td><strong>-1.1</strong></td>
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</table>
## APPENDIX B (Cont'd.)

### Varsity Control

<table>
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<tr>
<th>Subject</th>
<th>Pre-test (Seconds)</th>
<th>Post-test (Seconds)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
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<td>42.0</td>
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<td>5.8</td>
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<tr>
<td>R.W.</td>
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<td>K.Y.</td>
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<td>-2.0</td>
</tr>
<tr>
<td>D.R.</td>
<td>45.3</td>
<td>45.8</td>
<td>0.5</td>
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<tr>
<td>G.W.</td>
<td>48.5</td>
<td>46.0</td>
<td>-2.5</td>
</tr>
<tr>
<td>R.L.</td>
<td>40.5</td>
<td>39.8</td>
<td>-0.7</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td><strong>44.9</strong></td>
<td><strong>45.0</strong></td>
<td><strong>0.1</strong></td>
</tr>
</tbody>
</table>

### Varsity Experimental

<table>
<thead>
<tr>
<th>Subject</th>
<th>Pre-test (Seconds)</th>
<th>Post-test (Seconds)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>W.G.</td>
<td>46.3</td>
<td>46.0</td>
<td>-0.3</td>
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<tr>
<td>R.P.</td>
<td>46.3</td>
<td>46.3</td>
<td>0.0</td>
</tr>
<tr>
<td>A.P.</td>
<td>48.0</td>
<td>48.3</td>
<td>0.3</td>
</tr>
<tr>
<td>T.C.</td>
<td>43.8</td>
<td>43.5</td>
<td>-0.3</td>
</tr>
<tr>
<td>D.M.</td>
<td>42.8</td>
<td>43.3</td>
<td>0.5</td>
</tr>
<tr>
<td>R.S.</td>
<td>43.0</td>
<td>42.8</td>
<td>-0.2</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td><strong>45.0</strong></td>
<td><strong>45.0</strong></td>
<td><strong>0.0</strong></td>
</tr>
</tbody>
</table>
## APPENDIX C

### VERTICAL JUMP SCORES BEFORE AND AFTER TRAINING

<table>
<thead>
<tr>
<th>Subject</th>
<th>Class Control</th>
<th>Pre-test (Inches)</th>
<th>Post-test (Inches)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.S.</td>
<td></td>
<td>21.0</td>
<td>21.6</td>
<td>0.6</td>
</tr>
<tr>
<td>R.M.</td>
<td></td>
<td>20.0</td>
<td>18.9</td>
<td>-0.1</td>
</tr>
<tr>
<td>R.R.</td>
<td></td>
<td>20.3</td>
<td>21.7</td>
<td>1.4</td>
</tr>
<tr>
<td>R.A.</td>
<td></td>
<td>20.2</td>
<td>23.0</td>
<td>2.8</td>
</tr>
<tr>
<td>R.M.</td>
<td></td>
<td>23.4</td>
<td>26.0</td>
<td>2.6</td>
</tr>
<tr>
<td>C.M.</td>
<td></td>
<td>24.5</td>
<td>26.3</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td></td>
<td><strong>21.6</strong></td>
<td><strong>22.9</strong></td>
<td><strong>1.3</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subject</th>
<th>Class Experimental</th>
<th>Pre-test (Inches)</th>
<th>Post-test (Inches)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.H.</td>
<td></td>
<td>21.3</td>
<td>22.0</td>
<td>0.7</td>
</tr>
<tr>
<td>D.G.</td>
<td></td>
<td>22.5</td>
<td>22.3</td>
<td>-0.2</td>
</tr>
<tr>
<td>J.T.</td>
<td></td>
<td>18.6</td>
<td>20.3</td>
<td>1.7</td>
</tr>
<tr>
<td>B.T.</td>
<td></td>
<td>24.9</td>
<td>27.5</td>
<td>2.6</td>
</tr>
<tr>
<td>J.F.</td>
<td></td>
<td>27.1</td>
<td>26.6</td>
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<td>J.M.</td>
<td></td>
<td>22.3</td>
<td>22.7</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td></td>
<td><strong>22.8</strong></td>
<td><strong>23.6</strong></td>
<td><strong>0.8</strong></td>
</tr>
</tbody>
</table>
### Varsity Control

<table>
<thead>
<tr>
<th>Subject</th>
<th>Pre-test (Inches)</th>
<th>Post-test (Inches)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.T.</td>
<td>21.2</td>
<td>26.5</td>
<td>5.3</td>
</tr>
<tr>
<td>R.W.</td>
<td>24.6</td>
<td>26.4</td>
<td>2.2</td>
</tr>
<tr>
<td>K.Y.</td>
<td>21.3</td>
<td>23.5</td>
<td>2.2</td>
</tr>
<tr>
<td>D.R.</td>
<td>25.0</td>
<td>27.7</td>
<td>2.7</td>
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<tr>
<td>G.W.</td>
<td>21.9</td>
<td>24.9</td>
<td>3.0</td>
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<tr>
<td>R.L.</td>
<td>22.0</td>
<td>24.7</td>
<td>2.7</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td><strong>22.7</strong></td>
<td><strong>25.6</strong></td>
<td><strong>2.9</strong></td>
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</tbody>
</table>

### Varsity Experimental

<table>
<thead>
<tr>
<th>Subject</th>
<th>Pre-test (Inches)</th>
<th>Post-test (Inches)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>W.G.</td>
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<td>21.1</td>
<td>2.2</td>
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<tr>
<td>R.P.</td>
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<td>18.7</td>
<td>-0.6</td>
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<td>A.P.</td>
<td>17.2</td>
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<td>-0.4</td>
</tr>
<tr>
<td>T.C.</td>
<td>20.9</td>
<td>21.7</td>
<td>0.8</td>
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<tr>
<td>D.N.</td>
<td>24.8</td>
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<tr>
<td>R.S.</td>
<td>22.0</td>
<td>23.4</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td><strong>20.5</strong></td>
<td><strong>20.9</strong></td>
<td><strong>0.4</strong></td>
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</tbody>
</table>
## APPENDIX D

### WALL PULLEY SCORES BEFORE AND AFTER TRAINING

#### Class Control

<table>
<thead>
<tr>
<th>Subject</th>
<th>Pre-test (Repetitions)</th>
<th>Post-test (Repetitions)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.S.</td>
<td>57.0</td>
<td>52.5</td>
<td>- 4.5</td>
</tr>
<tr>
<td>R.M.</td>
<td>45.5</td>
<td>48.5</td>
<td>3.0</td>
</tr>
<tr>
<td>R.R.</td>
<td>57.5</td>
<td>51.0</td>
<td>- 6.5</td>
</tr>
<tr>
<td>R.A.</td>
<td>61.5</td>
<td>48.5</td>
<td>- 13.0</td>
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<tr>
<td>R.M.</td>
<td>47.0</td>
<td>39.5</td>
<td>- 7.5</td>
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<td>C.M.</td>
<td>34.5</td>
<td>46.0</td>
<td>11.5</td>
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</table>

| Means   | 53.3                   | 47.6                    | - 5.7      |

#### Class Experimental

<table>
<thead>
<tr>
<th>Subject</th>
<th>Pre-test (Repetitions)</th>
<th>Post-test (Repetitions)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.H.</td>
<td>55.5</td>
<td>53.5</td>
<td>- 2.0</td>
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<tr>
<td>D.G.</td>
<td>46.0</td>
<td>66.0</td>
<td>20.0</td>
</tr>
<tr>
<td>J.T.</td>
<td>35.5</td>
<td>44.0</td>
<td>8.5</td>
</tr>
<tr>
<td>B.T.</td>
<td>59.0</td>
<td>54.5</td>
<td>- 4.5</td>
</tr>
<tr>
<td>J.F.</td>
<td>54.0</td>
<td>50.0</td>
<td>- 4.0</td>
</tr>
<tr>
<td>J.M.</td>
<td>51.0</td>
<td>54.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

| Means   | 50.3                   | 53.8                    | 3.5        |
## APPENDIX D (Cont'd.)

### Varsity Control

<table>
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<tr>
<th>Subject</th>
<th>Pre-test (Repetitions)</th>
<th>Post-test (Repetitions)</th>
<th>Difference</th>
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<tbody>
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<tr>
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<td>K.Y.</td>
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<td>46.0</td>
<td>12.0</td>
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<tr>
<td>D.R.</td>
<td>55.5</td>
<td>61.5</td>
<td>6.0</td>
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<tr>
<td>G.W.</td>
<td>33.5</td>
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<td>65.0</td>
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Means 50.6 60.3 9.7

### Varsity Experimental

<table>
<thead>
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<th>Pre-test (Repetitions)</th>
<th>Post-test (Repetitions)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
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<td>64.5</td>
<td>0.0</td>
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<td>7.0</td>
</tr>
<tr>
<td>A.P.</td>
<td>54.0</td>
<td>62.5</td>
<td>8.5</td>
</tr>
<tr>
<td>T.C.</td>
<td>60.5</td>
<td>58.0</td>
<td>-2.5</td>
</tr>
<tr>
<td>D.M.</td>
<td>44.0</td>
<td>47.0</td>
<td>3.0</td>
</tr>
<tr>
<td>R.S.</td>
<td>46.0</td>
<td>54.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Means 53.4 57.3 3.9

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APPENDIX E

STATISTICAL ANALYSIS

**Formula for Two-Way Treatment Analysis of Variance**

**Total Sum of Squares** -
\[ \sum x^2 = \sum x^2 - C' \]

where:
- \( \sum x^2 \) = total sum of squares
- \( \sum x^2 \) = sum of the squares of the group scores
- \( C' \) = sum of the individual scores squared and divided by number of subjects in sample

**Treatment Sum of Squares** -

Treatment Sum of Squares = \[ \frac{x^2}{n} + \frac{x^2}{n} + \ldots - C' \]

where:
- \( \sum x^2 \) = total sum of squares
- \( C' \) = sum of individual scores squared and divided by number of subjects in sample
- \( n \) = number of subjects in each group

**Rows Sum of Squares** -

\[ \sum \frac{x^2}{n^*} + \sum \frac{x^2}{n^*} - C' \]

where:
- \( x^2 \) = sum of squares of the groups scores in rows
- \( C' \) = sum of individual scores squared and divided by number of subjects in sample
- \( n^* \) = number of subjects in row groups

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APPENDIX E (Cont'd.)

Column Sum of Squares-
\[
\frac{\sum \chi^2}{n^*} + \frac{\sum \chi^2}{n^*} - C'
\]

where:
- \( \chi^2 \) = sum of the squares of the groups scores in columns
- \( C' \) = sum of individual scores squared and divided by number of subjects in sample
- \( n^* \) = number of subjects in column groups

Interaction-
Row SS X Column SS = Treatments - Rows SS - Column SS

where:
- Row SS = row sum of squares
- Columns SS = column sum of squares
- Treatments = treatment sum of squares

Error-
Error = Total SS - Treatments

where:
- Total SS = total sum of squares
- Treatment SS = treatment sum of squares

F-Ratio
\[
F = \text{Mean squares for rows, columns and interaction divided by the error}
\]