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Muscular Strength, Muscular Endurance, and Circulorespiratory Endurance of University of North Dakota Varsity Wrestlers During the 1970-71 Season

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MUSCULAR STRENGTH, MUSCULAR ENDURANCE, AND CIRCULORESPIRATORY ENDURANCE OF UNIVERSITY OF NORTH DAKOTA VARSITY WRESTLERS DURING THE 1970-71 SEASON

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ABSTRACT

This study was conducted to establish those changes which occurred in muscular strength, muscular endurance, and circulorespiratory endurance over a one season period. Pre-season, pre-Christmas, post-Christmas, and post-season tests were administered to eleven University of North Dakota varsity wrestlers. The tests included the twelve minute run-walk, used to measure circulorespiratory endurance, and two weight training lifts--the bench press and the prone row, used to measure muscular strength and endurance. Each of the lifts was administered to test muscular responses four ways: static strength, static endurance, dynamic strength, and dynamic endurance.

A Randomized Block Analysis of Variance and the Dunn's c Test were used to analyze the results at the 0.05 level of significance. Significant gains occurred in the dynamic strength prone row test. Significant losses occurred in static endurance bench press and prone row. Gains also occurred in the static strength bench press and the twelve minute run-walk. Losses occurred in dynamic strength bench press, dynamic endurance prone row and bench press.

CHAPTER I

INTRODUCTION

Many studies have been conducted to evaluate the strength and endurance gains from static and dynamic training programs. Few investigations in these areas have been applied to the sport of wrestling.

Among those studies which determined significant changes in muscular strength and endurance only static strength instruments were used. These instruments included a back-leg dynamometer, a grip dynamometer, and a cable tensiometer.

Morrison (1) measured the back and leg strength and the cardiovascular performance of intercollegiate wrestlers. A cable tensiometer and back-leg dynamometer were used to measure strength. In another study, Rasch, et al. (2) compared college wrestlers total proportional strength to the strength of members of a physical education wrestling class. The muscular strength was composed of the four dynamometer scores: right grip, left grip, leg lift, and back lift. The sum of the dynamometer scores were converted to strength per pound of body weight. Johnson (3) tested strength of the back, legs, and arms. The back and leg strength were tested with a dynamometer and arm strength was tested with a cable tensiometer. All raw scores were converted into a unit strength score by dividing the recorded raw strength scores in pounds by the weight of the individual subject.

Although the above studies show the results of static instrument testing, there is evidence that a program of dynamic conditioning should be measured by dynamic instruments. Berger (4) found that a static strength test was not as accurate as a dynamic strength test in measuring changes in strength resulting from a dynamic muscle training program. Similarly, he found that a dynamic strength test was not as accurate as a static strength test in measuring changes in strength resulting from static muscle training. Martens, et al. (5) confirmed Berger's findings by reporting the need for a dual strength test when static and dynamic strength training programs are to be compared. On the other hand, Bender, et al. (6) reported that the strength necessary to perform a dynamic movement could be measured by isometric (static) techniques. Bender reasoned that failure in a given movement may be caused by a lack of strength at a specific angle in the range of motion.

These studies illustrate contradictory evidence over the practice of using only static instruments to measure muscular changes. Not only does the evidence indicate the need for appropriate methods of measurement, it also suggests the need for accurate identification of specific muscles involved in a particular sport. Since wrestling involves certain muscle areas more than others, the identification and testing of those specific muscles should provide a more accurate measurement upon which to base an evaluation of wrestling performance.

Nearly all muscles come into play at one time or another during a wrestling match. However, the muscles of the shoulder girdle and upper extremity are the main focal point of activity. These muscles include the anterior and posterior deltoids, pectoralis major,

latissimus dorsi, teres major, biceps brachii, triceps, and the forearm muscles.

In the referee position, for example, the shoulder and arm muscles are of major importance. By pulling and pushing, the offensive wrestler attempts to break his opponent down or to turn him over for a pin. The defensive wrestler on the other hand uses the shoulder and arm muscles in an effort to obtain a reverse or an escape from his opponent.

Among other aspects to examine are the types of muscle contractions which involve eccentric and concentric contractions. In an eccentric contraction such as a stand up, the offensive wrestler has his arms and hands pulled from around his opponent's waist, as the defensive wrestler obtains an escape. In a concentric contraction, the offensive wrestler maintains his grip and prevents his opponent from obtaining an escape.

The intensity and duration of the exercise bout, and how they influence the training program, must also be examined. For example, static strength is involved when two wrestlers are interlocked in a maneuver exerting maximum muscle tension where neither is able to overcome his opponent's resistance. If this muscle tension is prolonged for a period of time then static muscular endurance is being applied.

Dynamic strength on the other hand, is evident when either wrestler applies maximum strength in executing a maneuver in which joint-movement and muscle length changes. Dynamic muscular endurance is applied in the same manner as the dynamic muscular strength movements except that less than maximum strength is applied in doing a

particular manuever more than once, as in a switch-reswitch-switch combination. These factors in a wrestling conditioning program are best developed by a systematic training program which adheres to the principles of overload, progression, frequency, regularity, specificity and diversity.

Overload is accomplished by increasing the amount of work that the muscles perform. Progression is applied to a program by establishing a day to day routine, in which the rate of repetition, resistance, duration, and intensity are increased daily to ensure overload. Frequency and regularity involves controlling the number of practices and the interval between those practices.

Wrestling practices usually range from five to seven periods each week with heavy resistance work on alternating days to allow sufficient time between workouts to recover from fatigue. Other wrestling programs are arranged so that exercise of heavy resistance can be included in every practice, but with different parts of the body being exercised on alternate days of practice. Specificity must play an important part in every practice session. Exercises and drills which compare to competitive wrestling are desirable. Diversity, on the other hand, is incorporating changes from the regular routine in an effort to prevent boredom and nonproductivity.

Klatz (7) described a typical wrestling training program as one that starts with strengthening exercises, goes into wrestling with the drilling of wrestling moves, and ends with a conditioning phase.

Although the basic elements of conditioning and practice programs vary with each coach, most programs are typical of those described

by Klatz. These basic elements vary mainly in intensity, duration, and the fundamental moves that are taught. The different training programs may result in one program producing better apparent results than another, or a particular program not producing the results expected. Unless the results of a training program are measured and evaluated, the improvement in that program may not be evident. By measuring performance, the coach has an objective basis upon which to evaluate the training program, thus ensuring a base for determining the progress being made by the wrestlers.

Martens, et al. (5) conducted an investigation to determine the relationship between phasic strength and static strength, phasic strength and phasic endurance, static strength and static endurance, and phasic endurance and static endurance. The findings showed a significant relationship between phasic and static strength, but no significant relationship between the strength and endurance measures nor between the endurance scores.

Berger (4) attempted to determine the changes in dynamic strength produced by static training, and the changes in static strength produced by dynamic training. A correlation of 0.622 was calculated for static and dynamic strength scores.

McGlynn (8) investigated relationships between maximum strength and endurance and maximum strength and percentage of maximum strength before and after an extended period of isometric training. The findings showed a significant relationship between maximum strength and endurance and a negative relationship between maximum strength and percentage of maximum strength.

Berger, et al. (9) directed a study to determine whether performing ten repetitions with ten repetitions maximum for one set was more effective for increasing strength than performing ten repetitions for one set, but each repetition required a maximum or near maximum effort. This was achieved by reducing the load gradually, commencing with the one repetition maximum load for the first repetition. The loads at each repetition were commensurate to a subject's strength and fatigue. The results indicated that among lifters with no previous lifting experience, the weight training program employing maximum or near maximum loads for each of ten repetitions was more effective for increasing strength than was a program involving ten repetitions with maximum load.

Berger (10) investigated the relationship between maximum strength, as measured with 1-RM on the bench press lift, and dynamic muscular endurance, as measured by one half the weight of the maximum dynamic strength lift. The results showed a significant difference between dynamic strength and dynamic endurance. Also, it was concluded that individuals with high dynamic strength may have less relative muscular endurance with loads of fifty percent of maximum dynamic strength than weaker individuals.

Cotten (11) reported that the increase in duration of a sustained voluntary isometric contraction at fifty percent of maximum or greater, is due to an increase in strength. However, results indicated the endurance is the factor responsible for the increase in duration of a twenty-five percent of maximum contraction.

Tuttle, et al. (12) investigated the relationship between

maximum back and leg strength to back and leg endurance. The results indicated that individuals with the greater maximum strength have a greater absolute strength endurance index. Also, stronger individuals can maintain a smaller proportion of their maximum back and leg strength than those with less initial strength.

Berger (13) conducted a study to determine the feasibility of using chinning strength to predict total dynamic strength. The 1-RM chin included bodyweight plus the load added to the body. The conclusion was drawn that a 1-RM chin is an accurate means for predicting total dynamic strength.

Berger (14) tested eighty-three male college students for dynamic strength, static strength, and motor ability. The conclusions showed a significant relationship between motor ability and both static and dynamic strength. Also, dynamic strength was more highly related to motor ability than static strength.

Berger, et al. (15) studied the relationship between the AAHPER Youth Fitness Test and total dynamic strength. The correlation coefficient between the AAHPER Youth Fitness Test and total dynamic strength indicated the relatively high importance of the dynamic strength component in this fitness test.

Berger, et al. (16) conducted a study to determine whether static or dynamic leg strength was more related to leg power. It was concluded that no significant difference existed between the two.

Morrison (1) studied leg, back, and arm muscular changes and the cardiovascular fitness of college wrestlers throughout the 1965-66 season. Arm strength was measured by a cable tensiometer, and leg and

back strength was measured by the back-leg dynamometer. It was found that leg strength did increase significantly during the experimental period. Nonsignificant losses were reported for arm strength and cardiovascular fitness, and nonsignificant gains were reported for back strength.

Rasch, et al. (2) administered a total proportional strength test to members of a college physical education class and to members of a college wrestling squad. The test consisted of four dynamometer test items--right group, left group, back lift, and leg lift. The results indicated that no significant changes occurred in the mean scores of the physical education class or the college wrestling squad after training.

Bender, et al. (17) conducted a study to determine the effectiveness of isometric contraction and isotonic movement for strength development as related to the strength level of the individual prior to application of the exercise regimens. The findings indicated that individuals who were initially lower in strength gained more force with the application of stool stepping, whereas those who were initially higher in strength gained more force with isometrics.

Capen (18) investigated the effects of systematic weight training on strength, or athletic power, and on muscular and circulorespiratory endurance. The results showed that weight training does not result in muscular tightness and in a decrease of the speed of muscular contraction as was commonly assumed. It seemed that weight training was effective in developing muscular strength and circulorespiratory endurance.

In light of those specific and most prominent factors involved in practicing and conditioning wrestlers, it appears as if testing for specific muscular strength, muscular endurance and circulorespiratory changes could aid any coach in obtaining a better understanding of his wrestling training program. Such an understanding would then enhance the coach's effectiveness in prescribing additional exercise to improve the performance of his wrestlers.

Definition of Terms

Dynamic muscular strength: the capacity of an individual to exert maximum voluntary muscular force to complete one repetition of maximum load.

Static muscular strength: The capacity of an individual to exert maximum voluntary muscular force against an object with no apparent change in angle of joint or length of the muscle.

Dynamic muscular endurance: The capacity of an individual to perform as many voluntary full repetitions as possible as a continuous rate with resistance equal to twenty-five percent of the dynamic strength measurement.

Static muscular endurance: The capacity of an individual to sustain a voluntary muscle contraction with resistance equal to twenty-five percent of the static strength measurement for as long a period as possible without change in joint angle or muscle length.

Circulorespiratory endurance: The capacity of the lungs, heart, arteries and veins to extract oxygen from the atmospheric air and deliver it to the muscles, buffer lactic acid, and expel carbon dioxide.

One repetition maximum (1-RM): The maximum resistance an individual can overcome in completing one repetition.

CHAPTER II

METHODOLOGY

Identification of the Test

The test consisted of a twelve minute run-walk item and two weight training lifts: a bench press and a prone row, both performed in a prone position. The run-walk item measured the circulorespiratory endurance, and the lifts measured muscular changes in four ways: static strength, static endurance, dynamic strength, and dynamic endurance.

The bench press was designed to measure muscular changes in the triceps, pectoralis major, and anterior deltoid muscules. The prone row in a prone position was designed to measure muscular changes in the biceps brachii, triceps, posterior deltoid, teres major, and latissimus dorsi muscles. These two weight training lifts involve primarily the same muscles which were discussed in Chapter I as being specifically involved in the muscles of the shoulder area and arm.

Description of Testing Platform

The base, the platform, the upright supports, and the brace were all made of wood, and measured as follows:

main lifting platform and base = 2" x 12", 7' long

upright supports = 2" x 12", 42" long

brace = 2" x 4", 5' long

spacer (on top of the 2" x 12" platform) = 5" x 12", 4' long. A metal "T" track was made from 1" x 1" "T" bar metal. Five evenly spaced bolts anchored the "T" track to the base. A trolley and an attached chain, which could slide along the "T" track, served as one point of attachment for the cable in measuring static strength. The chain provided easy adjustment of the cable length, and the trolley provided easy admustment for a perpendicular pulling angle. Figure 1 shows the lifting platform.

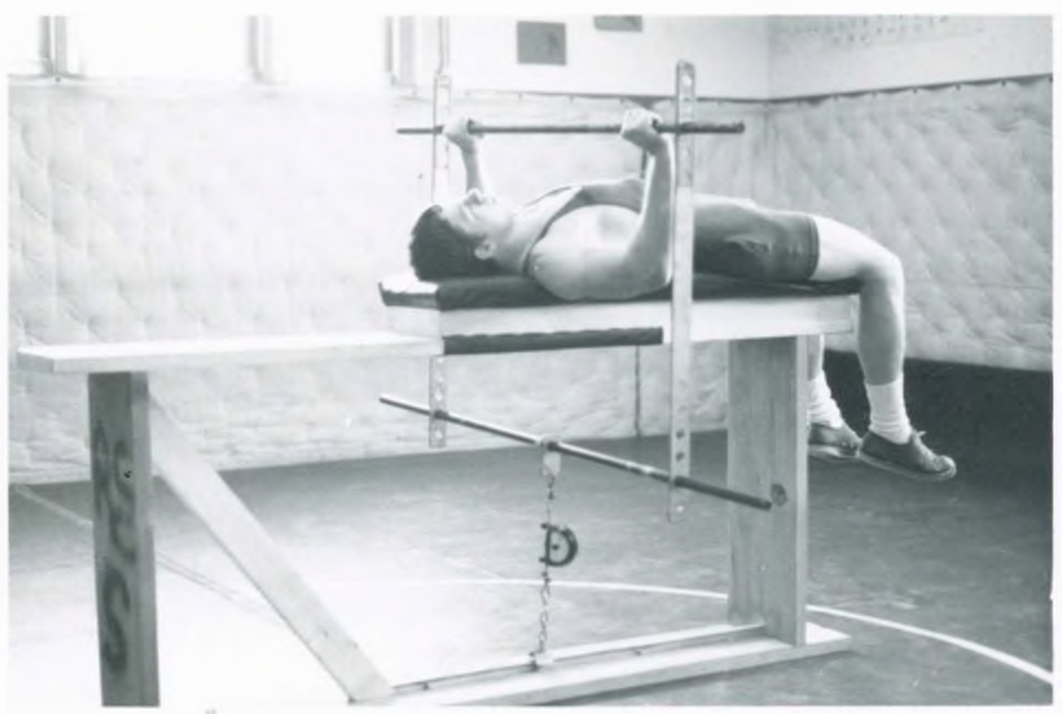

Fig. 1.--The lifting platform

Characteristics of the Test

Objectivity - The objectivity of the test was controlled by:

1. The investigator being the only test administrator.

2. The instrumentation which controlled the subject's position during the test.

3. The cable tensiometer which gives objective measurements.

(The cable tensiometer was calibrated at the University of North Dakota Engineering Department.)

Reliability - A pilot study was conducted in 1970 to determine the reliability of the test items. The test was administered to six freshmen wrestlers at the University of North Dakota, and repeated with the same group two days later. A rank difference correlation between the tests produced the following Rho values:

TABLE 1

TEST-RETEST RHO ESTIMATES FOR THE PRONE ROW AND BENCH PRESS

Test Items	Rho Values (Prone Row)	Rho Values (Bench Press)
Dynamic Strength	0.94	0.99
Static Strength	1.00	0.96
Dynamic Endurance	0.72	0.42
Static Endurance	0.66	1.00

A reliability coefficient of 0.976 for the twelve minute run-walk test was determined by Doolittle et al. (19). This reliability was determined in a test-retest using 149 male subjects.

Validity - Since each test item for the strength and endurance was low in complexity and was used specifically to test those muscles involved in wrestling, the test items were accepted at face validity.

The validity of the twelve minute run-walk was established by Cooper (20) when he compared the performance of the twelve minute run to the treadmill maximal oxygen consumption test. The correlation coefficient between these tests was 0.897. Since the maximal oxygen consumption test is generally accepted as the best single measure of

circulorespiratory fitness and because of the high correlation between this and the twelve minute run-walk item, the twelve minute test was accepted as a valid measure of circulorespiratory endurance.

Subjects

A nonprobability sample of twenty-five prospective University of North Dakota varsity wrestlers were tested prior to the start of the 1970-71 season. The final sample consisted of eleven of the original twenty-five subjects. The other fourteen subjects were dropped from the study owing to absences from the testing periods, or failure to remain in the wrestling program.

Test Procedures and Dates

The nine items of the test were administered to the subjects over a two day period. Mondays and Tuesdays were selected as test days since they followed a weekend which provided a period of recovery from practice and competition. The pattern of the two day testing was as follows: Monday - static strength bench press, dynamic strength prone row, static endurance bench press, dynamic endurance prone row, and the twelve minute run-walk; Tuesday - static strength prone row, dynamic strength bench press, static endurance prone row, and dynamic endurance bench press. The four testing periods (of two days each) were arranged as follows: the first week of organized wrestling practice, the week before Christmas vacation, the first week after Christmas vacation, and the week preceding the conference wrestling tournament. These testing periods occurred on the following dates as shown in Table 2.

TABLE 2

NAME OF TEST PERIODS AND TEST DATES

Pre-Season Test	October 15-16, 1970
Pre-Christmas Test	December 14-15, 1970
Post-Christmas Test	January 18-19, 1971
Post-Season Test	February 22-23, 1971

Unit of Measurement - The performance for the twelve minute run-walk test was scored as the number of whole laps that the runner completed, plus the number of completed quarters of the last lap. For example: 12.75 laps. Figure 2 shows the lap divisions.

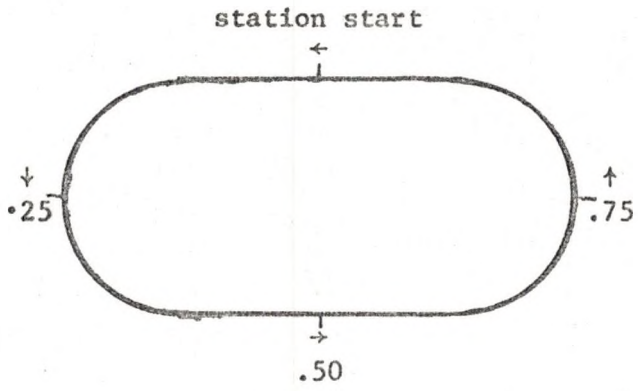

Fig. 2.--The lap divisions for scoring the twelve minute run-walk test

Item Description and Figures

Item I: Prone Row

A. Dynamic strength lift:

B. Dynamic endurance lift:

1. Body position - The subject assumed a prone position

on the bench, with the top of his shoulders even with the raised area of the bench. The legs were extended parallel to the bench. The arms were allowed to hang perpendicular to the body with palms turned in the direction of the head.

2. Prone row dynamic contraction - When the subject was in position to make the lift, the weighted bar was placed in the palms. (All York Olympic weights were calibrated by the University of North Dakota Engineering Department.) The subject, with an even, continuous pulling motion, rowed the weights upward to the bench. When the bar touched the bench and the weights were lowered to starting position, the repetition was complete. The elbow was kept tight to the body during the lift. The grip on the bar was as wide as the shoulders.
3. Units of measurement - Dynamic strength was measured in pounds of weight lifted in one maximum repetition. Dynamic endurance was measured as the maximum number of repetitions with weights equal to twenty-five percent of the dynamic strength lift. Figures 3 and 4 show the dynamic strength prone row and dynamic endurance prone row test items.

Fig. 3.--Dynamic strength and endurance prone row, starting position of lift

Fig. 4.--Dynamic strength and endurance prone row, top position of lift

C. Static strength:

1. Body position - The subject assumed a facedown position on the raised area of the bench with the top of the shoulders even with the raised area. The legs were extended parallel to the bench. The arms were bent at

the elbow at a ninety degree angle, with the palms turned in the same direction as the head.

2. Prone row static contraction - When the subject was in position to perform the static row, the bar was placed in the palms, and the cable quickly adjusted for length. The cable tensiometer was attached to the steel cable, and the subject executed the static row with a continuous, even pull until maximum row strength was attained.

3. Units of measurement - Static strength was measured in units of pounds by the cable tensiometer. Figure 5 shows the static strength prone row test item.

Fig. 5.--Static strength prone row

D. Static endurance:

1. Body position - The subject assumed a facedown position on the raised area of the bench with the top of the shoulders even with the raised area. The legs were

extended parallel to the bench. The arms were bent at the elbows at a ninety degree angle, with palms turned in the same direction as the head.

2. Prone row static contraction - When the subject was in position to perform the static row, an Olympic Bar with weights equal to twenty-five percent of weight registered on the cable tensiometer was placed in the palms.

3. Unit of measurement - Static endurance was measured by the number of seconds the subject was able to maintain a ninety degree angle at the elbow. Figure 6 shows the static endurance prone row test item.

Fig. 6.--Static endurance prone row

Item II: Bench Press

A. Dynamic strength lift:

B. Dynamic endurance lift:

1. Body position - The subject assumed a supine position

on the bench. The subjects head was even with the end of the raised area of the bench. The legs were bent at the knees, allowing the lower half of the leg to extend over the end of the bench. The grip on the bar was equal to the width of the shoulders. The arms were abducted to a ninety degree angle. The elbows were bent at a ninety degree angle to aid in adjustment of the grip. When the width of the grip was established, the bar and weights were lowered to the chest.

2. Bench press dynamic contraction - The bench press lift was performed with an even, continuous pushing and lowering of the weight from the chest to fully extended arms, then back to the chest.

3. Unit of measurement - Dynamic strength was measured in pounds of weight lifted in one maximum repetition. Dynamic endurance was measured as the maximum number of repetitions done with twenty-five percent of maximum weight lifted in the dynamic strength test item. Figures 7 and 8 show the dynamic strength and endurance bench press test item.

C. Static strength:

1. Body position - The subject assumed a supine position on the bench. The head was even with the end of the raised area. The legs were bent at the knees allowing the lower half of the leg to extend over the end of the bench. The arms were abducted to a ninety degree

angle, parallel to the floor. The elbows were bent to allow the forearm to form a ninety degree angle to the floor.

Fig. 7.--Dynamic strength and endurance bench press, starting position

Fig. 8.--Dynamic strength and endurance bench press with fully extended arms

2. Bench press static contraction - When the subject was positioned for the static contraction, the bar was placed in the palms and the cable quickly adjusted for length. The bar was supported by the assistants until the actual static contraction had started. The subject executed a static bench press with an even, continuous pushing motion until maximum static strength was attained.

3. Unit of measurement - Static strength was measured in units of pounds by the cable tensiometer. Figure 9 shows the static strength bench press test item.

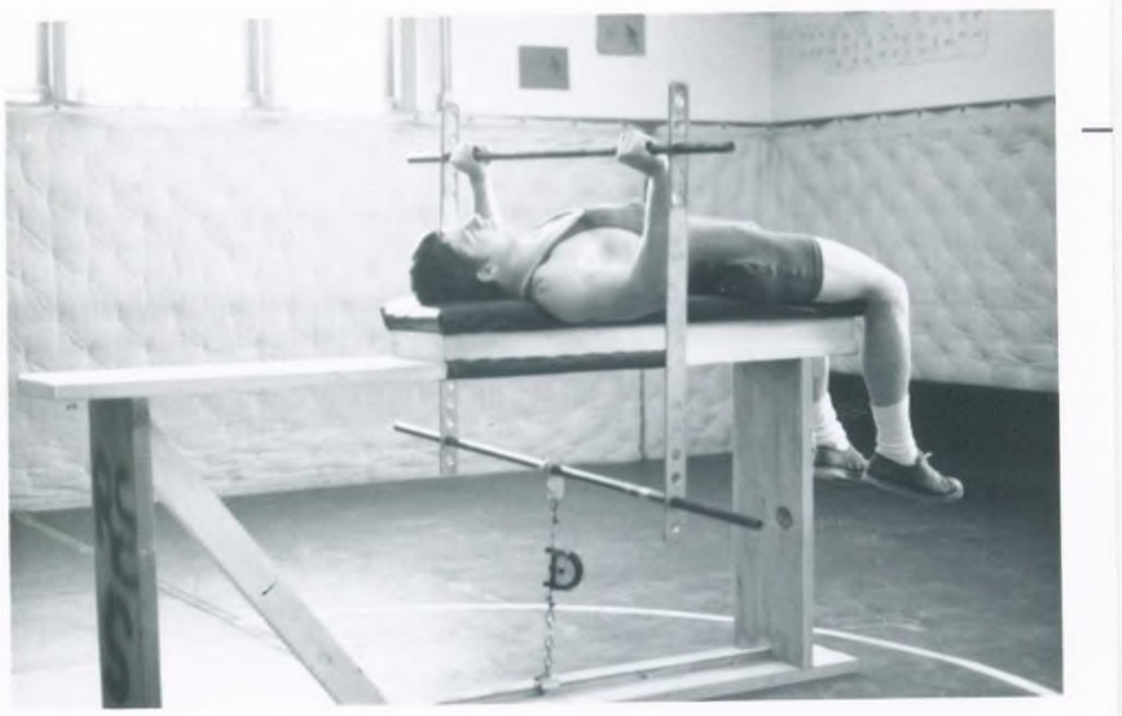

Fig. 9.--Static strength bench press

D. Static endurance:

1. Body position - The subject assumed a supine position on the bench. The head was even with the end of the raised area. The legs were bent at the knees, allowing the lower half of the leg to extend over the end of

the bench. The arms were abducted to a ninety degree angle, parallel to the floor. The elbows were bent to allow the forearm to form a ninety degree angle to the floor.

2. Bench press static contraction - When the subject was positioned for the static contraction, the Olympic Weights were placed in the palms. The weight of the bar equalled twenty-five percent of the weight registered on the cable tensiometer.

3. Unit of measurement - Static endurance was measured by the number of seconds the subject was able to maintain a ninety degree angle at the elbow. Figure 10 shows the static endurance bench press test item.

Fig. 10.--Static endurance bench press

Item III: The Twelve Minute Run-Walk

A. Test procedures:

The wrestlers were divided into two equal lines and a coin was tossed to determine which line would run the twelve minute test first. The group that won the toss was given the choice of being the first or second group to run. If they chose to be the first group to run, the second group acted as counters. Once the first group had completed the twelve minute run, the counters became runners and the runners became counters.

CHAPTER III

TREATMENT AND ANALYSIS OF THE DATA

Statistical Procedure

The data collected and compiled were transferred from score cards to I.B.M. fortran sheets, then to I.B.M. cards.

A Randomized Block Analysis of Variance was performed using a general linear model and solving by use of a multiple linear regression. This analysis partitioned the variance into the following sources: subjects, tests, and error within groups. Significance tests were run at the .05 level. Dunn's c Test was applied to those items which were significant at the .05 level to compare the mean scores for each of the nine test items used during the four test periods.

The following test items were checked for significant differences:

1. dynamic strength - prone row
2. dynamic endurance - prone row
3. static strength - prone row
4. static endurance - prone row
5. dynamic strength - bench press
6. dynamic endurance - bench press
7. static strength - bench press

8. static endurance - bench press

9. twelve minute run-walk.

Six comparisons were made for each of the four test periods.

Null Hypothesis

There was no significant difference among the nine test items over the four test periods.

Analysis of Results

Dynamic strength: Prone row

The means and standard deviations for prone row test were as follows: 179 ± 20 pounds for the pre-season test; 188 ± 18 pounds for the pre-Christmas test; 181 ± 20 pounds at post-Christmas; 190 ± 20 pounds at post-season.

The mean difference between the pre-season and pre-Christmas tests showed a significant increase of eight pounds; from pre-Christmas to post-Christmas, a significant decrease of six pounds; and from post-Christmas to post-season a significant increase of nine pounds. These differences are illustrated in Table 3.

The trend of the mean scores for this test indicated an increase, a decrease, and an increase. A significant difference between pre-season and post-season performance was also shown. All other comparisons, pre-season to post-Christmas, pre-Christmas to post-season, were not significant.

TABLE 3

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS
FOR THE DYNAMIC STRENGTH PRONE ROW
OVER THE FOUR TESTING PERIODS

	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
Mean	179	187	181	190
Mean Difference		+8	-6	+9
Standard Deviations	19	18	20	21
Significant Increase at the .05 Level				
Significant Decrease at the .05 Level				

Dynamic strength: Bench press

The means and standard deviations for the bench press test were as follows: 173 ± 26 pounds for the pre-season test; 170 ± 27 pounds for the pre-Christmas test; 168 ± 26 pounds for the post-Christmas; 171 ± 27 pounds for the post-season. These differences are illustrated in Table 4.

The trend of this test indicated a decrease in the mean performance for the group from pre-season to post-Christmas and a slight gain to post-season. None of the test period comparisons, however, was significant for this test.

TABLE 4

SIGNIFICANCE OF THE DIFFERENCES BETWEEN MEANS
OF THE DYNAMIC STRENGTH BENCH PRESS
OVER THE FOUR TESTING PERIODS

	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
Means	173	170	168	171
	No Significant Increases or Decreases			
Mean Difference		-3	-2	+3
Standard Deviations	26	27	26	27
Significant Increase at the .05 Level				
Significant Decrease at the .05 Level				

Dynamic endurance: Prone row

The means and standard deviations for the prone row test were as follows: 113 ± 40 for the pre-season test; 101 ± 25 repetitions for the pre-Christmas test; 84 ± 11 repetitions for the post-Christmas test; 98 ± 15 repetitions for the post-season test.

The mean difference between the pre-season test showed a significant decrease of 29 repetitions, to post-Christmas. These differences are illustrated in Table 5.

TABLE 5

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS
OF THE DYNAMIC ENDURANCE PRONE ROW
OVER THE FOUR TESTING PERIODS

	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
	No Significant Increases			
Means	113	101	84	98
Mean Differences		-12	-15	+14
Standard Deviations	40	25	11	15
Significant Increase at the .05 Level		⌜——⌝		
Significant Decrease at the .05 Level		⌞——⌟		

The trend of the mean scores for this test indicated a decrease in dynamic endurance through the pre-Christmas test and the post-Christmas test. From post-Christmas to post-season, a slight increase in dynamic endurance was shown, but the increase was fifteen repetitions less per individual than of the pre-season score.

Dynamic endurance: Bench press

The means and standard deviations for the bench press test were as follows: 91 ± 17 repetitions for the pre-season test; 86 ± 12 repetitions for the pre-Christmas test; 84 ± 17 repetitions for the post-Christmas test; 93 ± 15 repetitions for the post-season test.

These differences are illustrated in Table 6.

TABLE 6

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF THE DYNAMIC ENDURANCE BENCH PRESS OVER THE FOUR TESTING PERIODS

	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
Means	91	86	84	93
	No Significant Increases or Decreases			
Mean Difference		-5	-2	+9
Standard Deviations	17	12	17	15
Significant Increase at the .05 Level				
Significant Decrease at the .05 Level				

The trend of the mean scores for this test indicated a slight but continuous decrease in dynamic endurance from the pre-Christmas test through the post-Christmas test. From post-Christmas to post-season a nonsignificant gain was recorded.

Static strength: Prone row

The means and standard deviations for the prone row test were as follows: 243 ± 33 pounds for the pre-season test; 239 ± 32 pounds for the pre-Christmas test; 249 ± 30 pounds for the post-Christmas test; 242 ± 29 pounds for the post-season test. These differences are

illustrated in Table 7.

TABLE 7

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF THE STATIC STRENGTH PRONE ROW OVER THE FOUR TESTING PERIODS

	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
Means	243	239	249	242
	No Significant Increases or Decreases			
Mean Difference		-4	+10	-7
Standard Deviations	33	32	29	29
Significant Increase at the .05 Level				
Significant Decrease at the .05 Level				

The trend of the test indicated a decrease, an increase, and a decrease, but none of these differences were significant.

Static strength: Bench press

The means and standard deviations for the bench press test were as follows: 196 ± 37 pounds for the pre-season test; 207 ± 34 pounds for the pre-Christmas test; 201 ± 34 pounds for the post-Christmas test; 206 ± 34 pounds for the post-season test. These differences are illustrated in Table 8.

TABLE 8

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS
OF THE STATIC STRENGTH BENCH PRESS
OVER THE FOUR TESTING PERIODS

	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
Means	19 6	207	201	206
	No Significan t Increases or Decreases			
Mean Difference		+11	-6	+5
Standard Deviations	37	34	34	34
Significant Increase at the .05 Level		┌──────┐		
Significant Decrease at the .05 Level		└──────┘		

The trend of the mean scores for this test indicated an increase, a decrease, and an increase, but was not significant.

Static endurance: Prone row

The means and standard deviations for the prone row test were as follows: 238 ± 61 seconds for the pre-season test; 222 ± 40 seconds for the pre-Christmas test; 175 ± 32 seconds for the post-Christmas test; 184 ± 32 seconds for the post-season test.

The mean difference between pre-season and post-Christmas tests showed a significant decrease of sixty-three seconds; between pre-season and post-season tests, a significant decrease of fifty-four

seconds; between pre-Christmas and post-Christmas tests, a significant decrease of forty-seven seconds; between pre-Christmas and post-season, a significant decrease of forty-eight seconds. These differences are illustrated in Table 9.

TABLE 9

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF THE STATIC ENDURANCE PRONE ROW OVER THE FOUR TESTING PERIODS

	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
Mean	238	222	175	184
Mean Difference		-16	-47	+9
Standard Deviations	61	40	32	32
Significant Increase at the .05 Level				
Significant Decrease at the .05 Level				

The trend of the mean scores for that test indicated a significant decrease, significant decrease, and a slight increase of nine seconds, but not to a significant level.

Static endurance: Bench press

The means and standard deviations for the bench press test were as follows: 204 ± 35 seconds for the pre-season test; 172 ± 45 seconds

for the pre-Christmas test; 165 ± 32 seconds for the post-Christmas test; 147 ± 36 seconds for the post-season test.

The mean difference between pre-season and pre-Christmas tests showed a significant decrease of thirty-two seconds; between pre-season and post-Christmas tests, a significant decrease of thirty-five seconds; between pre-season and post-season tests, a significant decrease of fifty-six seconds; between pre-Christmas and post-Christmas tests, a significant decrease of twenty-five seconds; between post-Christmas and post-season tests a significant decrease of eighteen seconds. These differences are illustrated in Table 10.

TABLE 10

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF THE STATIC ENDURANCE BENCH PRESS OVER THE FOUR TESTING PERIODS

	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
	No Significant Increases			
Means	204	172	165	147
Mean Difference		-32	-7	-18
Standard Deviations	35	45	32	36
Significant Increase at the .05 Level		⌐——————⌐		
Significant Decrease at the .05 Level		⌊——————⌋		

The trend of the mean scores for the test indicated a significant decrease throughout the season.

Twelve minute run-walk

The mean and standard deviations for the twelve minute run-walk test were as follows: 20.75 ± 2 laps for the pre-season test; 22.50 ± 2 laps for the pre-Christmas test; 22.50 ± 1 laps for the post-Christmas test; 23.00 ± 2 laps for the post-season test. These differences are illustrated in Table 11.

TABLE 11

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF THE TWELVE MINUTE RUN-WALK TEST OVER THE FOUR TESTING PERIODS

	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
Means	20.75	22.50	22.50	23.00
	No Significant Increases or Decreases			
Mean Differences		+1.75	0.0	+.50
Standard Deviations	2	2	1	2
Significant Increase at the .05 Level		┌──────┐		
Significant Decrease at the .05 Level		└──────┘		

The trend of the mean scores for this test indicated an increase from pre-season to pre-Christmas and again from post-Christmas to post-season, although not at a significant level.

CHAPTER IV

DISCUSSION

Wrestling is generally thought of as an endurance sport and the training is usually dynamic. Findings from the present study indicated which muscular changes occurred as the result of the University of North Dakota wrestling training program. Gains occurred in circulorespiratory endurance; however, losses occurred in muscular endurance. In spite of these losses in muscular endurance, the wrestlers appeared to be at their peak of physical condition and wrestling performance.

The "endurance factor" in wrestling then may be more closely related to circulorespiratory endurance. This circulorespiratory endurance was evident by the increase in the running distance for the University of North Dakota wrestlers on the twelve minute run-walk test.

On the other hand, had the University of North Dakota wrestling training program been more specific in terms of muscular endurance exercises the wrestlers may have developed more muscular endurance, thus improving wrestling performance. However, the endurance losses could also have been attributed to factors that McGlynn (8) and Tuttle (12) found: that stronger subjects fatigue faster than the weaker ones.

Shaver (21) on the other hand, indicated that "the trained individuals who have the greatest muscular strength likewise have the greatest relative muscular endurance." Since conditioning and testing involve such variety it is also suggested that factors such as motivation or lack of motivation of the subjects, or the reliability of endurance tests, could have accounted for some difference in results and could have been a factor in apparent endurance losses.

Other muscular changes that occurred were: significant gains in dynamic strength prone row, nonsignificant gains in the static strength bench press, and nonsignificant losses in dynamic strength bench press and static strength prone row.

The gains indicated in the dynamic strength prone row muscles might have been due to the fact that these muscles were included in the dynamic exercise conditioning program. However, both dynamic strength prone row and static strength bench press could very likely have been due to the wrestling itself. If the University of North Dakota conditioning program had included static strength exercises, gains in static strength may have been greater.

As shown by the test results, only the muscles used in the prone row increased in dynamic strength, and only the bench press muscles increased in static strength. Neither test item showed increases in both strength types. It may be considered that wrestling practice caused these specific muscular changes or that a gain in one type of strength could mean a loss in the other type. Berger (4) stated: "The assumption that an increase in dynamic strength guarantees a proportionate increase in static strength has not been substantiated."

The strongest possibility however appeared to have been that the University of North Dakota conditioning program lacked the combination of exercises needed to adequately develop both types of strength.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

A battery of tests were administered to the University of North Dakota varsity wrestlers at four intervals over a period of one wrestling season. The twelve minute run-walk test was used to test circulorespiratory endurance, and two weight training lifts--the bench press and the prone row--were used to test muscular endurance and muscular strength. Each of the two lifts tested muscular strength and endurance in four ways: static strength, static endurance, dynamic strength, and dynamic endurance.

The test results were analyzed by the Multiple Linear Regression Analysis of Variance and Dunn's c Test.

Conclusions

On the basis of the results of these tests and in respect to the sample size and other related factors, the conclusions were as follows:

1. Dynamic strength as measured by the prone row measured significant gains as the result of the training program.

2. Static strength as measured by the bench press and circulorespiratory endurance as measured by the twelve minute run-walk indicated a training effect, but not to a significant level.

3. Dynamic and static endurance as measured by the prone row and bench press indicated no significant training effect.

Recommendations

In respect to the findings and conclusions of this study the recommendations are as follows:

1. There is a need to conduct an identical study for comparison and verification of the results of this study.

2. With consideration of the losses in static and dynamic endurance, there is a need for further research to determine if an improvement in endurance would enhance wrestling performance.

3. With consideration of the gains in dynamic strength prone row muscles and static strength bench press muscles, there is a need for research to determine if further development of these specific strength gains would result in improved wrestling performance.

APPENDIX A

TABLE 12

THE ANALYSIS OF THE DYNAMIC STRENGTH PRONE ROW TEST

Raw Scores, Means, Standard Deviations

Subject	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
D.L.	175	185	190	195
S.M.	155	175	150	160
E.L.	215	225	220	230
J.D.	155	170	165	170
R.H.	155	160	160	165
R.S.	180	195	190	205
T.M.	185	175	175	175
J.W.	205	205	205	210
S.C.	175	175	170	190
J.L.	180	195	180	195
G.A.	185	195	185	195
Mean	178.636	186.818	180.909	190.000
S.D.	19.505	18.476	20.226	21.095

TABLE 13

THE ANALYSIS OF THE DYNAMIC STRENGTH PRONE ROW TEST

Analysis of Variance

Summary	Degrees of Freedom	S S	M S	F
Subjects	10	14801.133	1480.113	46.352*
Tests	3	904.541	301.513	9.442*
Error	30	957.953	31.932	
Total	43	16663.633		

* Significant at the .05 level (Critical value for F = 2.92; df = 3 and 30).

TABLE 14

THE ANALYSIS OF THE DYNAMIC STRENGTH PRONE ROW TEST

Comparisons Between Means by Dunn's c Test

$178.636 - 186.818 = \frac{8.182}{2.411} = 3.394$ *	$186.818 - 180.909 = \frac{5.909}{2.411} = 2.451$ *
$178.636 - 180.909 = \frac{2.273}{2.411} = .943$	$186.818 - 190.000 = \frac{3.182}{2.411} = 1.320$
$178.636 - 190.000 = \frac{11.364}{2.411} = 4.713$ *	$180.909 - 190.000 = \frac{9.091}{2.411} = 3.771$ *

* is significant at the .05 level; df = 10 and 3; Dunn's significant value 2.50; Error mean square = 31.932; Dunn's estimate for the significance:

$$c = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{MS\left(\frac{1}{n} + \frac{1}{n}\right)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{31.932\ (.182)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{5.812}} =$$

$$\frac{\bar{X}_1 - \bar{X}_2}{2.411}$$

TABLE 15

THE ANALYSIS OF THE DYNAMIC STRENGTH BENCH PRESS TEST

Raw Scores, Means, Standard Deviations

Subject	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
D.L.	160	160	150	165
S.M.	155	155	145	135
E.L.	215	225	220	225
J.D.	135	135	145	145
R.H.	145	150	150	150
R.S.	160	150	150	165
T.M.	170	165	165	155
J.W.	205	185	200	195
S.C.	175	155	160	170
J.L.	175	180	160	170
G.A.	205	205	200	205
Mean	172.727	169.545	167.727	170.909
S.D.	25.920	26.782	26.303	27.186

TABLE 16

THE ANALYSIS OF THE DYNAMIC STRENGTH BENCH PRESS TEST

Analysis of Variance

Summary	Degrees of Freedom	S S	M S	F
Subjects	10	26772.832	2677.283	56.282 *
Tests	3	147.918	49.242	1.042
Error	30	1427.074	47.569	
Total	43	28347.645		

* Significant at the .05 level (Critical value for F = 2.92; df = 3 and 30).

TABLE 17

THE ANALYSIS OF THE DYNAMIC STRENGTH BENCH PRESS TEST

Comparisons Between Means by Dunn's c Test

$172.727 - 169.545 = \frac{3.182}{2.942} = 1.082$	$169.545 - 167.727 = \frac{1.818}{2.942} = .618$
$172.727 - 167.727 = \frac{5.000}{2.942} = 1.700$	$169.545 - 170.909 = \frac{1.364}{2.942} = .464$
$172.727 - 170.909 = \frac{1.818}{2.942} = .618$	$167.727 - 170.909 = \frac{3.182}{2.942} = 1.082$

* is significant at the .05 level ; df = 10 and 3; Dunn's significant value 2.50; Error mean square 47.569; Dunn's estimate for the significance:

$$c = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{MS\left(\frac{1}{n} + \frac{1}{n}\right)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{47.579\ (.182)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{8.659}} =$$

$$\frac{\bar{X}_1 - \bar{X}_2}{2.942}$$

TABLE 18

THE ANALYSIS OF THE STATIC STRENGTH PRONE ROW TEST

Raw Scores, Means, Standard Deviations

Subject	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
D.L.	239	227	257	240
S.M.	202	205	225	213
E.L.	317	317	332	313
J.D.	202	195	217	201
R.H.	207	233	245	232
R.S.	270	249	249	247
T.M.	247	229	247	237
J.W.	247	249	247	249
S.C.	247	227	239	250
J.L.	257	247	239	223
G.A.	239	260	245	257
Mean	234.091	239.818	249.273	242.000
S.D.	33.375	32.090	29.652	29.010

TABLE 19

THE ANALYSIS OF THE STATIC STRENGTH PRONE ROW TEST

Analysis of Variance

Summary	Degrees of Freedom	S S	M S	F
Subjects	10	35357.488	3537.749	32.269 *
Tests	3	542.177	180.726	1.649
Error	30	3287.129	109.571	
Total	43	39186.848		

* Significant at the .05 level (Critical value for F = 2.92; df = 3 and 30).

TABLE 20

THE ANALYSIS OF THE STATIC STRENGTH PRONE ROW TEST

Comparisons Between Means By Dunn's c Test

$243.091 - 239.818 = \frac{3.273}{4.466} = .733$	$239.818 - 249.273 = \frac{9.455}{4.466} = 2.117$
$243.091 - 249.273 = \frac{6.182}{4.466} = 1.384$	$239.818 - 242.000 = \frac{2.182}{4.466} = .489$
$243.091 - 242.000 = \frac{1.091}{4.466} = .244$	$249.273 - 242.000 = \frac{7.273}{4.466} = 1.629$

* is significant at the .05 level; df = 10 and 3; Dunn's significant value 2.50; Error mean square = 260.710; Dunn's estimate for the significance:

$$c = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{MS\left(\frac{1}{n} + \frac{1}{n}\right)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{109.571\ (.182)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{19.942}} =$$

$$\frac{\bar{X}_1 - \bar{X}_2}{4.466}$$

TABLE 21

THE ANALYSIS OF THE STATIC STRENGTH BENCH PRESS TEST

Raw Scores, Means, Standard Deviations

Subject	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
D.L.	161	181	206	184
S.M.	261	206	203	184
E.L.	231	257	261	269
J.D.	149	157	161	165
R.H.	155	171	171	178
R.S.	186	191	154	181
T.M.	181	207	186	197
J.W.	209	239	231	253
S.C.	176	199	199	211
J.L.	206	207	191	206
G.A.	241	261	247	241
Mean	196.000	206.909	200.909	206.273
S.D.	36.856	33.516	34.180	34.009

TABLE 22

THE ANALYSIS OF THE STATIC STRENGTH BENCH PRESS TEST

Analysis of Variance

Summary	Degrees of Freedom	S S	M S	F
Subjects	10	40056.961	4005.691	15.004 *
Tests	3	862.971	287.657	1.078
Error	30	8008.953	266.965	
Total	43	48928.902		

* Significant at the .05 level (Critical value for F = 2.92; df = 3 and 30).

TABLE 23

THE ANALYSIS OF THE STATIC STRENGTH BENCH PRESS TEST

Comparisons Between Means By Dunn's c Test

$196.000 - 206.909 = \frac{10.909}{6.971} = 1.565$	$206.909 - 200.909 = \frac{6.000}{6.971} = .861$
$196.000 - 200.909 = \frac{4.909}{6.971} = .704$	$206.909 - 206.273 = \frac{.636}{6.971} = .091$
$196.000 - 206.273 = \frac{10.273}{6.971} = 1.474$	$200.909 - 206.273 = \frac{5.364}{6.971} = .769$

* is significant at the .05 level; df = 10 and 3; Dunn's significant value 2.50; Error mean square = 266.965; Dunn's estimate for the significance:

$$c = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{MS\left(\frac{1}{n} + \frac{1}{n}\right)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{266.965\ (.182)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{48.588}} =$$

$$\frac{\bar{X}_1 - \bar{X}_2}{6.971}$$

TABLE 24

THE ANALYSIS OF THE STATIC ENDURANCE BENCH PRESS TEST

Raw Scores, Means, Standard Deviations

Subject	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
D.L.	194	164	175	160
S.M.	130	98	112	90
E.L.	243	211	191	173
J.D.	205	2 04	173	164
R.H.	217	227	223	205
R.S.	226	154	150	120
T.M.	181	170	155	129
J.W.	191	132	158	138
S.C.	193	147	158	152
G.L.	265	246	196	186
G.A.	194	137	120	100
Mean	203.545	171.818	164.636	147.000
S.D.	35.198	45.126	32.281	35.547

TABLE 25

THE ANALYSIS OF THE STATIC ENDURANCE BENCH PRESS TEST

Analysis of Variance

Summary	Degrees of Freedom	S S	M S	F
Subjects	10	40056.961	4005.696	15.364 *
Tests	3	18415.230	6138.410	23.545 *
Error	30	7821.313	260.710	
Total	43	66292.504		

* Significant at the .05 level (Critical value for F = 2.92; df = 3 and 30).

TABLE 26

THE ANALYSIS OF THE STATIC ENDURANCE BENCH PRESS TEST

Comparisons Between Means By Dunn's c Test

$203.545 - 171.818 = \frac{31.727}{6.888} = 4.606$ *	$171.818 - 164.636 = \frac{7.182}{6.888} = 1.043$
$203.545 - 164.636 = \frac{38.909}{6.888} = 5.649$ *	$171.818 - 147.000 = \frac{24.818}{6.888} = 3.603$ *
$203.545 - 147.000 = \frac{56.545}{6.888} = 9.209$ *	$164.636 - 147.000 = \frac{17.636}{6.888} = 2.560$ *

* is significant at the .05 level; df = 10 and 3; Dunn's significant value 2.50; Error mean square = 260.710; Dunn's estimate for the significance:

$$c = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{MS\left(\frac{1}{n} + \frac{1}{n}\right)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{260.710\ (.182)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{47.449}} =$$

$$\frac{\bar{X}_1 - \bar{X}_2}{6.888}$$

TABLE 27

THE ANALYSIS OF THE DYNAMIC ENDURANCE BENCH PRESS TEST

Raw Scores, Means, Standard Deviations

Subject	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
D.L.	80	75	74	90
S.M.	87	72	98	91
E.L.	102	100	79	93
J.D.	63	65	61	70
R.H.	81	95	100	111
R.S.	96	89	102	114
T.M.	124	90	111	112
J.W.	93	89	67	81
S.C.	80	89	90	103
J.L.	109	103	75	84
G.A.	82	83	64	76
Mean	90.636	86.364	83.727	93.182
S.D.	16.687	11.724	17.217	15.105

TABLE 28

THE ANALYSIS OF THE DYNAMIC ENDURANCE BENCH PRESS TEST

Analysis of Variance

Summary	Degrees of Freedom	S S	M S	F
Subjects	10	6050.699	605.070	5.412 *
Tests	3	592.062	197.354	1.765
Error	30	3354.152	111.805	
Total	43	9996.910		

* Significant at the .05 level (Critical value for F = 2.92; df = 3 and 30).

TABLE 29

THE ANALYSIS OF THE DYNAMIC ENDURANCE BENCH PRESS TEST

Comparisons Between Means By Dunn's c Test

$90.636 - 86.364 = \frac{4.272}{4.511} = .947$	$86.364 - 83.727 = \frac{2.637}{4.511} = .585$
$90.636 - 93.182 = \frac{6.909}{4.511} = 1.536$	$86.364 - 93.182 = \frac{6.818}{4.511} = 1.511$
$90.636 - 93.182 = \frac{2.456}{4.511} = .564$	$83.727 - 93.182 = \frac{9.455}{4.511} = 2.096$

* is significant at the .05 level; df = 10 and 3; Dunn's significant value 2.50; Error mean square = 1.118; Dunn's estimate for the significance:

$$c = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{MS\left(\frac{1}{n} + \frac{1}{n}\right)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{111.805\ (.182)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{20.349}} =$$

$$\frac{\bar{X}_1 - \bar{X}_2}{4.511}$$

TABLE 30

THE ANALYSIS OF THE STATIC ENDURANCE PRONE ROW TEST

Raw Scores, Means, Standard Deviations

Subject	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
D.L.	201	198	179	180
S.M.	197	247	171	205
E.L.	265	224	158	160
J.D.	265	252	234	221
R.H.	304	291	191	187
R.S.	177	187	172	186
T.M.	176	207	164	187
J.W.	295	251	168	157
S.C.	220	195	157	207
J.L.	352	241	221	220
G.A.	169	144	115	113
Means	238.273	221.545	175.455	183.909
S.D.	61.448	40.409	32.054	31.653

TABLE 31

THE ANALYSIS OF THE STATIC ENDURANCE PRONE ROW TEST

Analysis of Variance

Summary	Degrees of Freedom	S S	M S	F
Subjects	10	48859.953	4885.992	5.744 *
Tests	3	29682.496	9894.164	11.630 *
Error	30	25520.438	850.681	
Total	43	104062.750		

* Significant at the .05 level (Critical value for F = 2.92; df = 3 and 30).

TABLE 32

THE ANALYSIS OF THE STATIC ENDURANCE PRONE ROW TEST

Comparisons Between Means By Dunn's c Test

$238.273 - 221.545 = \frac{16.728}{12.443} = 1.344$	$221.545 - 175.455 = \frac{46.090}{12.443} = 3.704$ *
$238.273 - 175.455 = \frac{62.818}{12.443} = 5.048$ *	$221.545 - 183.909 = \frac{37.636}{12.443} = 3.025$ *
$238.273 - 183.909 = \frac{54.364}{12.443} = 4.369$ *	$175.455 - 183.909 = \frac{8.454}{12.443} = .679$ *

* is significant at the .05 level; df = 10 and 3; Dunn's significant value 2.50; Error mean square 850.681; Dunn's estimate for the significance:

$$c = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{MS\left(\frac{1}{n} + \frac{1}{n}\right)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{850.681\ (.182)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{154.824}} =$$

$$\frac{\bar{X}_1 - \bar{X}_2}{12.443}$$

TABLE 33

THE ANALYSIS OF THE DYNAMIC ENDURANCE PRONE ROW TEST

Raw Scores, Means, Standard Deviations

Subject	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
D.L.	112	100	100	103
S.M.	98	102	90	84
E.L.	106	93	85	94
J.D.	50	75	71	75
R.H.	111	110	84	95
R.S.	125	125	90	102
T.M.	87	80	77	112
J.W.	116	101	88	87
S.C.	134	79	61	125
J.L.	213	161	97	114
G.A.	88	82	77	89
Mean	112.727	100.727	83.636	98.182
S.D.	40.177	25.068	11.440	14.744

TABLE 34

THE ANALYSIS OF THE DYNAMIC ENDURANCE PRONE ROW TEST

Analysis of Variance

Summary	Degrees of Freedom	S S	M S	F
Subjects	10	14966.500	1496.650	4.103 *
Tests	3	4707.996	1569.332	4.303 *
Error	30	10941.992	364.733	
Total	43	30616.484		

* Significant at the .05 level (Critical value for F = 2.92; df = 3 and 30).

TABLE 35

THE ANALYSIS OF THE DYNAMIC ENDURANCE PRONE ROW TEST

Comparisons Between Means By Dunn's c Test

$112.727 - 100.727 = \frac{12.000}{8.147} = 1.473$	$100.727 - 83.636 = \frac{17.091}{8.147} = 2.098$
$112.727 - 83.636 = \frac{29.091}{8.147} = 3.570$ *	$100.727 - 98.182 = \frac{2.545}{8.147} = .312$
$112.727 - 98.182 = \frac{17.091}{8.147} = 1.785$	$83.636 - 98.182 = \frac{14.546}{8.147} = 1.785$

* is significant at the .05 level; df = 10 and 3; Dunn's significant value 2.50; Error mean square 364.733; Dunn's estimate for the significance:

$$c = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{MS\left(\frac{1}{n} + \frac{1}{n}\right)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{364.733\ (.182)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{66.381}} =$$

$$\frac{\bar{X}_1 - \bar{X}_2}{8.147}$$

TABLE 36

THE ANALYSIS OF THE TWELVE MINUTE RUN-WALK TEST

Raw Scores, Means, Standard Deviations

Subject	Pre-Season	Pre-Christmas	Post-Christmas	Post-Season
D.L.	22.50	22.00	22.75	23.50
S.M.	21.00	22.50	22.50	23.25
E.L.	16.00	19.25	19.25	19.75
J.D.	21.75	23.75	24.00	24.50
R.H.	24.25	26.00	25.00	26.00
R.S.	21.50	22.25	22.25	23.00
T.M.	22.25	23.50	23.00	23.25
J.W.	19.50	22.50	22.75	23.00
S.C.	20.00	22.00	21.50	23.00
J.L.	19.00	22.25	22.25	22.25
G.A.	20.75	22.50	21.75	22.75
Mean	20.773	22.591	22.455	23.114
S.D.	2.167	1.610	1.453	1.506

TABLE 37

THE ANALYSIS OF THE TWELVE MINUTE RUN-WALK TEST

Analysis of Variance

Summary	Degrees of Freedom	S S	M S	F
Subjects	10	10615.870	1061.587	30.465 *
Tests	3	3393.594	1131.198	32.463 *
Error	30	1045.370	34.846	
Total	43	15054.840		

* Significant at the .05 level (Critical value for F = 2.92; df = 3 and 30).

TABLE 38

THE ANALYSIS OF THE TWELVE MINUTE RUN-WALK TEST

Comparisons Between Means By Dunn's c Test

$20.773 - 22.591 = \frac{1.818}{2.518} = .722$	$22.591 - 22.455 = \frac{.136}{2.518} = .0054$
$20.773 - 22.455 = \frac{1.682}{2.518} = .668$	$22.591 - 23.114 = \frac{.523}{2.518} = .208$
$20.773 - 23.114 = \frac{2.341}{2.518} = .930$	$22.455 - 23.114 = \frac{.659}{2.518} = .262$

* is significant at the .05 level; df = 10 and 3; Dunn's significant value 2.50; Error mean square = 34.846; Dunn's estimate for the significance:

$$c = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{MS\left(\frac{1}{n} + \frac{1}{n}\right)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{34.846\ (.182)}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{6.341}} =$$

$$\frac{\bar{X}_1 - \bar{X}_2}{2.518}$$

APPENDIX B

DESCRIPTION OF THE UNIVERSITY OF NORTH DAKOTA WRESTLING PRACTICE ROUTINE

Wrestling practice began with running from ten to twenty minutes on a 1/12 mile indoor track in the University of North Dakota fieldhouse. The duration and the intensity was increased as the season progressed. After the run was completed, each wrestler reported to the wrestling room for a five to ten minute conditioning and stretching program.

This phase of the workout included the following exercises: toe touches, leg lifts in prone position, trunk twisters, wood choppers, jumping jacks, push-ups, sit-ups, hurdle exercises, wrestler's bridge, jap dips, handstand push-ups, and straddle pull-ups.

In performing the above exercises the wrestlers were instructed to start the exercise slow but to increase the speed until maximum speed was attained and to continue until told to stop. As the season progressed the intensity and duration also increased to maintain sufficient overload. On Mondays, Wednesdays and Fridays the duration of the routine was reduced to provide time for the use of the Universal Gym in strength conditioning. The strength conditioning continued throughout the training season, except for days prior to competition.

The strength conditioning program consisted of pull-ups, military presses, bench presses, regular and reverse curls, lateral dumbbell raises, upright rowing, parallel bar dips, sit-ups on an

inclined bench, squats, and latissimus dorsi exercises. During this phase of the training, wrestlers were required to complete as many repetitions as possible in ten to fifteen seconds. Each wrestler performed each exercise twice. Following conditioning on the Universal Gym the wrestlers participated in thirty to forty minutes of wrestling related drills and instruction in wrestling. During the next twenty to thirty minutes of practice, each wrestler took part in wrestling drills or wrestling matches. Practice then concluded with either power-conditioning or reaction drills.

As the season progressed, the intensity and duration of each phase increased and the practices were varied to add diversity. These variations included swimming, playing basketball, or wrestling tag team matches such as sometimes shown on television.

APPENDIX C

TABLE 39

CALIBRATION OF CABLE TENSIOMETER*

Dead Mass Load Pounds	Tensiometer Reading	Dead Mass Load Pounds	Tensiometer Reading
110	25	230	69
120	28	240	73
130	32	250	76
140	38	260	78
150	42	270	81
160	45	280	84
170	50	290	87
180	52	300	90
190	56	310	92
200	60	320	94
210	63	330	98
220	66	340	100

* Cable Tensiometer, Model T5-6007-118, Serial No. 10189, 3/32 Diameter Cable.

TABLE 40

CALIBRATION OF YORK OLYMPIC WEIGHT SET

York Olympic Bar (without collars)	45.00 pounds
York Olympic Bar Collar	2.50 pounds
Two and a half pound weight	2.63 pounds
Five pound weight	5.12 pounds
Ten pound weight	10.00 pounds
Twenty-five pound weight	25.00 pounds
Thirty-five pound weight	35.00 pounds
Forty-five pound weight	45.00 pounds

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