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THE PHYSICAL WORK CAPACITY OF INTERCOLLEGIATE FOOTBALL PLAYERS DURING A SEASON OF TRAINING

by

© DALE HARVEY PHILLIP SCHULHA

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled THE PHYSICAL WORK CAPACITY OF INTERCOLLEGIATE FOOTBALL PLAYERS DURING A SEASON OF TRAINING submitted by DALE HARVEY PHILLIP SCHULHA in partial fulfilment of the requirements for the degree of Master of Science.

S. W. Mendryk
(Supervisor)

[illegible]

Ross B. J. Macnab

DATE May 22, 1974

DEDICATION

To my mother and father, for their lasting love, direction and encouragement.

The purpose of this study was to compare beginning of pre-season, end of pre-season, and end of regular season physical work capacity scores of intercollegiate football players.

Twenty-six intercollegiate football players were tested throughout the eleven week training period. Each subject was administered a modified Sjostrand PWC_{170} test at each testing session.

Within the limits of this study, the following conclusions have been made:

(1) There was a significant increase between beginning of pre-season and end of pre-season mean PWC_{170} and PWC_{170}/kg. scores for the football players, as a group.

(2) There was a significant increase between beginning of pre-season and end of pre-season mean PWC_{170} and PWC_{170}/kg. scores for the defensive linemen. However, no significant differences were apparent between beginning of pre-season and end of pre-season mean PWC_{170} or PWC_{170}/kg. scores for offensive linemen, offensive backs or defensive backs.

(3) There was no significant difference between beginning of pre-season and end of regular season mean

PWC_{170} or PWC_{170}/kg. sco[illegible]
players, as a group.

(4) There were no significant differences [illegible] beginning of pre-season and end of [illegible] mean PWC_{170} or PWC_{170}/kg. scores for any [illegible] four positions.

(5) There was no significant difference between [illegible] of pre-season and end of regular season mean PWC_{170} or PWC_{170}/kg. scores for the football players, as a group.

(6) There were no significant differences between end of pre-season and end of regular season mean PWC_{170} or PWC_{170}/kg. scores for any of the four positions.

(7) There were no significant differences in mean PWC_{170} or PWC_{170}/kg. scores between any of the four positions at the beginning of the pre-season.

(8) There were no significant differences in mean PWC_{170} or PWC_{170}/kg. scores between any of the four positions at the end of the pre-season.

(9) There were no significant differences in mean PWC_{170} or PWC_{170}/kg. scores between any of the four positions at the end of the regular season.

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To the subjects, both football players and controls, who volunteered their time and energy.

To my wife, Bonnie, an eternal thank you for her love, understanding and unfailing patience.

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I. INTRODUCTION

The pre-season and in-season preparation of football players pose a number of problems. One problem is that of conditioning. Football players must reach a minimum level of conditioning during the pre-season period and maintain or improve this level of conditioning throughout the season. This is of utmost importance if a player is to participate to his maximum potential in every game situation.

Canadian high school and university football teams are generally limited to a two or three week pre-season period. Obviously this is a very short time in which to prepare a football team, both physically and mentally, for the upcoming season. However, it would appear that the football coach realizes the importance of conditioning for his players and therefore a great deal of emphasis is usually placed on this aspect of the game during the pre-season period.

Once the pre-season period is over it would be valuable to know if the relative emphasis on conditioning remains at this high peak throughout the season. That is, as the season progresses and more practice time is spent on team skills and team execution, is it possible that a deconditioning effect occurs during the season? This is something that the football coach should be aware of when developing an in-season practice schedule.

It should be noted that physical conditioning is somewhat of a nebulous concept and there are a number of ways in which the physical condition of athletes can be measured. Some methods of measurement require expensive equipment, highly skilled testers, and a great deal of time and effort by the subject. On the other hand, some methods require less expensive equipment, less skill by the testers, and less time and effort by the subject. An example of the latter method is the modified Sjostrand Physical Work Capacity Test (1) which has been administered to the intercollegiate football players who have acted as the subjects for this study.

II. THE PROBLEM

The purpose of this study was to compare beginning of pre-season, end of pre-season, and end of regular season physical work capacity scores of intercollegiate football players as measured by a modified Sjostrand PWC_{170} test.

III. SUB-PROBLEMS

The following sub-problems were studied:

(1) The mean difference between beginning of pre-season and end of pre-season physical work capacity scores.

(2) The mean difference, by position, between beginning of pre-season and end of pre-season physical work capacity scores.

(3) The mean difference between beginning of pre-season and end of regular season physical work capacity scores.

(4) The mean difference, by position, between beginning of pre-season and end of regular season physical work capacity scores.

(5) The mean difference between end of pre-season and end of regular season physical work capacity scores.

(6) The mean difference, by position, between end of pre-season and end of regular season physical work capacity scores.

(7) The mean difference, by position, between physical work capacity scores at the beginning of the pre-season.

(8) The mean difference, by position, between physical work capacity scores at the end of the pre-season.

(9) The mean difference, by position, between physical work capacity scores at the end of the regular season.

IV. DELIMITATIONS

(1) The subjects used were twenty-six volunteer intercollegiate football players at the University of Alberta, during the 1973 season.

(2) The control subjects used were nineteen volunteer first year male Physical Education students at the University of Alberta.

(3) The experiment was limited to one submaximal method of measuring physical work capacity.

(4) All subjects were tested by the same tester on each occasion.

V. LIMITATIONS

(1) The experimenter was not able to obtain complete data on all members of the particular football team under study.

(2) The experimenter had no control over his subjects, except during the testing situations, and therefore could not eliminate activities other than practice and game situations which may have affected the physical work capacity scores.

(3) It was not possible for the experimenter to test his subjects during each week of the season and therefore no inferences can be drawn as to when the highest and lowest levels of physical work capacity did occur.

VI. DEFINITIONS AND ABBREVIATIONS OF TERMS

Physical Work Capacity. The capacity to perform prolonged physical work.

PWC_{170}. The capacity to perform prolonged physical work at a steady state heart rate of 170 beats per minute.

Steady State. The work situation where oxygen uptake equals the oxygen requirement of the tissues.

Kilopond (kp.). One kp. is the force acting on the mass of one kg. at normal acceleration of gravity.

Kilopond Metre (kpm.). A measure of work on the bicycle ergometer. This is a product of the tension setting on the ergometer, the distance travelled by the ergometer wheel in one revolution, and the number of pedal revolutions performed per minute.

Work Load. The calibrated frictional force applied to a friction belt which the subject must overcome to continue cycling at a rate of sixty revolutions per minute (2).

Pre-Season Period. The fourteen day formal practice period which immediately preceded the football team's first regular season game.

Offensive Linemen. Those football players whose primary position was one of the following: center, offensive guard, offensive tackle, or offensive end.

Offensive Backs. Those football players whose primary position was one of the following: quarterback, fullback, offensive halfback, wingback, or flanker.

Defensive Linemen. Those football players whose primary position was one of the following: defensive tackle, defensive end, or linebacker.

Defensive Backs. Those football players whose primary position was one of the following: corner-halfback, defensive halfback, or safety.

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CHAPTER II

REVIEW OF THE LITERATURE

I. PHYSICAL WORK CAPACITY

Many physiologists (1,2,3,4,5,6,7,8) are of the opinion that an individual's ability to perform prolonged physical work is a useful measure of cardiovascular fitness. This ability to perform prolonged physical work is termed physical work capacity (3,9,10,11,12).

An individual's physical work capacity is dependent on his ability to take up, transport and deliver oxygen to the working muscle (10). Therefore, maximal oxygen intake is generally considered to be the best single indicator of physical work capacity (2,4,10,13,14,15,16,17). However, indirect or submaximal methods of assessing physical work capacity (3,8) are also very evident in fitness testing today.

RELATIONSHIP BETWEEN MAXIMAL AND SUBMAXIMAL WORK TESTS

Although maximal oxygen intake is a very popular method of assessing physical work capacity, it may be inadvisable for a variety of reasons. Williams (18) lists four limitations which are inherent in the use of the maximal test. These include:

(1) There is no standard criterion to indicate when

the subject has reached his maximal intake level. Some investigators feel that the maximal level is reached when the oxygen consumption does not increase as the work load is increased. However, others may set a minimal value for the increase in oxygen consumption, such as 150 or 200 ml, when the work load is increased.

(2) Psychological factors may limit the subject from performing at his maximal physiological capacity.

(3) Direct measurement of maximal oxygen intake is relatively time consuming.

(4) The equipment necessary for such testing is rather expensive.

Astrand and Rodahl (3:348) also recognize the possible limitations of maximal work tests and emphasize that a maximal oxygen intake test should meet the following requirements:

(1) The work must involve large muscle groups.

(2) The work must be measurable and reproducible.

(3) The test conditions must be such that the results are comparable and repeatable.

(4) The test must be tolerated by all healthy individuals.

(5) The skill involved in the task should be simple and uniform in the population tested.

Resulting from the limitations of maximal exercise testing, submaximal tests (3,8,9,11,14,18,19) have been developed in an attempt to predict maximal aerobic capacity. Taylor

(17) states that the measurement of aerobic capacity indirectly reflects the state of efficiency of the cardiovascular system. Therefore, heart rate response to exercise may serve as an indicator of maximal aerobic capacity. Consequently, most submaximal physical work capacity tests use the heart rate response to a standardized work load as a measure of cardiorespiratory fitness (18).

Research (1,2,4,18,20) has also shown limitations of the submaximal test when used to predict maximal oxygen intake levels. These are:

(1) The relationship between heart rate and oxygen consumption during progressively increasing work loads is linear only to a point (2,4,18).

(2) An elevated resting heart rate may result in an underestimation of maximal aerobic capacity (2,18).

(3) Aerobic capacity values may be overestimated for older subjects and athletes (2,18).

However, there are still some useful applications of submaximal tests. These include:

(1) In repeated measures experiments, the subject serves as his own control and therefore, repeated submaximal tests at different time intervals may be indicative of training effects (18).

(2) In those tests where norms are established, an individual's score may be compared with set standards (18).

Taylor (21) compared the responses of a group of thirty-one subjects, aged nineteen to twenty-six, to submaximal and maximal work in repeat experiments. The subjects initially walked on a treadmill at a grade of five per cent and a speed of 108 meters per minute for four minutes. Upon completion of this submaximal test, the subjects had a four minute rest period. The maximal work consisted of running on the treadmill to exhaustion. The initial grade of the treadmill was five per cent and was elevated one per cent each minute. The speed of the treadmill was set at 162 meters per minute. The subjects were retested in three days. It was found that the heart rate and blood lactate were the most reliable submaximal measures.

Astrand and Saltin (5) conducted a study on four male and one female subjects in order to analyze how critical the duration of exercise is in relation to the determination of maximal oxygen intake. All subjects performed heavy exercise on a bicycle ergometer at a pedal frequency of fifty revolutions per minute. Work loads were varied in order that exhaustion would terminate exercise after two to eight minutes. The results indicated that aerobic capacity can be measured in a work test of from two to eight minutes duration. However, in studies of circulation and respiration during submaximal work it is concluded that the duration of work should exceed five minutes.

Cumming et al. (22) took repeated measures of aerobic capacity of twelve subjects, aged thirteen to sixteen, during a week of training at a youth track camp. The subjects consisted of six males and six females. The results indicated that a prediction of aerobic capacity from submaximal tests based on pulse rate did not give a true indication of changes in aerobic capacity.

Andersen (23) reported on the indirect evaluation of aerobic work capacity based on heart rate recordings during muscular exercises at submaximal intensities. He found the accuracy of estimating aerobic work capacity from heart rate recordings during submaximal work is less than the direct method of measuring maximal oxygen uptake. The coefficient of variation for the direct method of determining maximal oxygen uptake was three to five per cent whereas it was fifteen to twenty per cent for the indirect or submaximal method.

Astrand and Rodahl (3) concluded that an evaluation of the maximal effect of the oxygen-transporting system, based on studies at submaximal levels, should be done very carefully. Utmost caution was urged especially when dealing with individuals of different age groups. It was also noted that there are at least two situations when the submaximal work test has been very useful:

(1) In a clinical situation it is often valuable to include an exercise test in order to examine the cardiovascular system under functional stress (3).

(2) In evaluating whether or not a training program has been effective in improving the individual's circulatory capacity. In the work test on the bicycle ergometer, a counting of the heart rate

is sufficient for the evaluation (3).

Wilmore and Sigerseth (24) investigated the physical work capacity of sixty-two girls, seven to thirteen years of age. The subjects performed a progressively loaded, step-increment test on a bicycle ergometer. The results indicated that both the maximal and submaximal responses to the work capacity test had low correlations with maximal oxygen intake. It was found that only five of sixty-eight correlations between submaximal heart rates and maximal oxygen intake had significant coefficients at the .05 level. A correlation coefficient of .59 was found between maximal ventilation and maximal oxygen intake.

Rowell et al. (25) studied thirty-four male university students, aged eighteen to twenty-four, and found that submaximal pulse rates provided no reliable basis for prediction of maximal oxygen intake.

WORK CAPACITY IN TREADMILL AND BICYCLE EXERCISE

McArdle and Magel (26) compared the maximum oxygen intake and physical work capacity of twenty-three male college students. It was shown that the heart rate was significantly lower in the bicycle test during maximal oxygen intake. The results also indicated that physical work capacity measures at heart reates of 150 and 170 beats per minute were fairly similar on both the bicycle ergometer and treadmill.

Davies and Musgrove (27) conducted a two part study on thirty-six male subjects. The results led the investigators to conclude that the conventional method of expressing work capacity values on a bicycle ergometer, especially at high work loads, may be misleading. A second conclusion emphasized that inter-subject variation of bicycling skill may be small in subjects with minimal training on the ergometer.

Glassford et al. (28) compared four techniques of measuring maximal oxygen consumption in twenty-four male subjects aged seventeen to thirty-three. Three direct tests, two on a treadmill and one on a bicycle ergometer, and one indirect test, on a bicycle ergometer, were given to each subject. The results indicated that the two treadmill tests and the indirect bicycle ergometer test had significantly higher mean values than did the direct bicycle test. It was concluded that direct treadmill tests yield higher maximal oxygen uptake values than does the direct bicycle ergometer test. Inference was made that treadmill tests involve greater muscle mass than do bicycle tests and this may be related to the results.

Hermansen and Saltin (29) have concluded that maximal heart rate, oxygen consumption, arteriovenous oxygen difference, cardiac output, and stroke volume for a particular individual are usually higher on the treadmill than on the bicycle ergometer.

RELIABILITY OF WORK CAPACITY TESTS

Borg and Dahlstrom (30) studied forty-two military recruits who performed two bicycle ergometer tests. The initial test was performed in the summer of one year and then was repeated in the spring of the following year. The intra-test reliability coefficients were found to be as high as .97. These reliability coefficients were assessed by correlating the pulse rates with each other after two, four, and six minute work periods. The re-test correlation after eight months was .75.

Cumming and Danzinger (31) administered a bicycle ergometer test to nineteen boys and twenty-two girls. The subjects were tested in the spring and the fall of the same year. Although no figures were reported, it is stated that there was no significant difference between mean working capacity values for the two testing sessions.

Sime et al. (32) assessed the reliability of standardized ergometric tests on the treadmill and the bicycle. Thirteen male subjects, mean age of forty-nine, were studied on the treadmill. Forty-six male subjects, mean age of forty-eight, were studied on the bicycle ergometer. The results revealed that the mean of the second of a pair of tests was consistently less by 1.0 to 3.4 beats per minute than the mean of the first. It was also shown that intra-individual variability ranged from 2.0 to 6.7 beats per minute. This statistic was less for the treadmill subjects than for the bicycle subjects.

II. SJOSTRAND PWC_{170} TEST

DEVELOPMENT OF THE TEST

The Sjostrand Test is one of the most common submaximal physical work capacity tests in use at the present time (19). Sjostrand (8) introduced the possibility of indirect work capacity tests in 1947. The initial study (8) was designed to investigate the changes in the respiratory organs of workmen at an ore smelting works. The subjects were twenty ore smelting workmen, aged thirty-two to fifty. The test consisted of riding a bicycle ergometer at three ten minute work loads, and one four to six minute work load. The first three work loads were respectively set at 300, 600, and 900 kpm. per minute. The final work load was set at 1,200 kpm. per minute. Each subject rode the bicycle until his heart rate exceeded 175 beats per minute or until the heart rate rose more than ten beats per minute during constant work. Rarick (33) states that this study has led to the conclusion that the work load necessary to produce a heart rate of 170 beats per minute is associated with near maximal values for cardiac output and oxygen consumption.

Wahlund (34) modified the test by reducing the duration of each work load to 6½ minutes. The test was terminated when the subject could no longer pedal or when he had reached a work load of 1,200 kpm. per minute. The test was also designed so that the maximum heart rate at which work could be performed satisfactorily was set at 170 beats per minute (35). If this specified heart rate was not reached, the estimated work which would have been done at this heart rate was extrapolated from the known relationship between heart rate and work load (14).

Bengtsson (6) modified the test further when he studied the working capacity of seventy-six children, aged five to fourteen, and thirty-eight adults, aged fifteen to forty. The duration of each work load was reduced to six minutes. The pedalling rate was also modified and was set at either forty-five or sixty revolutions per minute. Three work loads were used and were adjusted so as to elicit a heart rate of between 125 and 130 beats per minute at the end of the first work period, between 140 to 150 beats per minute at the end of the second work period, and between 160 to 170 beats per minute at the end of the third and final work period.

Adams et al. (36) conducted a study on elementary and junior high school students and reduced the number of work periods from three to two. Each exercise period maintained a length of six minutes. The first work load was set to hopefully produce a heart rate of approximately 140 beats per minute and the second a heart rate of approximately 170 beats per minute.

Howell and Macnab (14) replaced the three six minute work periods with three four minute work periods. The duration of the test was therefore reduced from eighteen to twelve minutes. The desired heart rate response to the three work levels are between 115 to 130 beats per minute for the first exercise period, between 130 to 145 beats per minute for the second exercise period, and between 160 to 180 beats per minute for the final exercise period.

Steadward (37) modified Howell and Macnab's version of the test (14) so that the heart rate of each subject was monitored by an electrocardiograph only at the end of each four minute period of exercise. This is in contrast to the conventional method of monitoring the heart rate after every minute of exercise. The modified Sjostrand Test as stated by Steadward (37) is the basis of the test used in this study.

Sharkey (38) conducted a study on thirty-six male college students and altered the test so that each of the three work periods was 2½ minutes in duration. The initial work load was set at 300 kpm. per minute and was increased by 300 kpm. per minute for each of the following two work periods.

UNDERLYING CONCEPT

The Sjostrand Test is based on three principles:

(1) There is a linear relationship between heart rate, work load, and oxygen uptake. In other words, as the work load increases so does the heart rate and the oxygen uptake (14,19,35).

(2) At a given steady state heart rate, the more fit a person the more work he can do (14).

(3) A heart rate of 170 beats per minute is approximately eighty per cent of an individual's maximal oxygen uptake (19,34).

Therefore, it is apparent that this submaximal test measures physical work capacity concurrent with a steady state heart rate of 170 beats per minute (PWC_{170}).

DeVries (9) states that a heart rate of 170 beats per minute is designated in the Sjostrand Test because it is generally accepted as the level above which no significant increase in work load occurs.

Cumming and Danzinger (16) found that their subjects, aged ten and eleven, were working at seventy-three per cent of the maximal oxygen consumption at a heart rate of 170 beats per minute.

Astrand and Rhyming (4) concluded that a submaximal heart rate of between 125 to 170 beats per minute was the best indicator of an individual's aerobic capacity.

In light of the research which substantiates the Sjostrand Test, Knuttgen (19) has stated that determination of a steady state heart rate response to submaximal exercise is subject to certain errors. First, it is emphasized that assumptions must be made that all persons have the same resting heart rate and the same maximal heart rate. Knuttgen claims that these assumptions are false. Secondly, Knuttgen feels that the heart rate-work intensity relationship for any individual can be altered by environment, dehydration, blood loss, and/or day-to-day physiologic variations.

VALIDITY

Wahlund (34) concluded that oxygen consumption could be predicted from work load providing the subject had not reached the point of exhaustion. In sixty-six per cent of the subjects this estimation was accurate within a range of ± 8 per cent.

DeVries and Klafs (7) determined the correlation of the Sjostrand Test to a modified Mitchell, Sproule and Chapman Test. A correlation of .703, significant at the .01 level, was found between maximal oxygen intake and the Sjostrand Test. The value of this correlation was seen to decrease to .573, significant at the .05 level, when oxygen intake/kg was correlated to the Sjostrand Test expressed in kpm/min.

DeVries (9) found that the PWC_{170} test correlated well with the maximal oxygen uptake of college men, $r = .88$. The standard error of prediction of maximal oxygen uptake from the PWC_{170} test was ± 9.4 per cent.

Fedoruk (39) studied twenty-four male and twenty-four female university physical education students. He found that there was a significant difference, at the .05 level, between maximal oxygen uptake measures and Sjostrand work capacity measures for the females. There was no significant difference between maximal oxygen uptake and Sjostrand work capacity measures for the male subjects.

RELIABILITY

Zahar (40) studied thirty-eight high school students and found the Sjostrand Test to be a highly reliable measure of physical work capacity. The PWC_{170} Test was administered to each subject six times over a six-week period. The reliability coefficients between trials were, in order: .886, .894, .841, .877, and .947. All five correlations were significant at the .01 level.

[illegible]tts (41) studied the test-retest reliability of the PWC_{170} [illegible]t on nine male university students. The correlation [illegible] rel[illegible]lity for PWC_{170} scores was .89 and for PWC_{170}/kg scores [illegible] .95.

III. EFFECTS OF TRAINING ON PHYSICAL WORK CAPACITY

Astrand (2) states that training aims at increasing the possibilities for an individual to perform a certain task. He also stipulates that a high standard of physical condition allows an individual to stand heavy muscular work for a long time. The effects of training are specified as (2:322):

(1) At rest, a constant or slightly decreased basal metabolism is seen during the training period.

(2) The pulse rate is slower.

(3) The stroke volume increases.

(4) The heart volume increases as well as the residual volume of the heart.

(5) During submaximal work with a fixed intensity, in uncomplicated forms of exercise, a fairly constant, possibly a somewhat improved mechanical efficiency will be observed.

(6) While performing maximal work, the pulse rate is

about the same for trained and untrained persons.

(7) Aerobic capacity increases as well as capacity to accumulate greater oxygen debt.

Newman (35) studied thirty-nine male and female swimmers over a season of training. The training period was from nineteen to twenty-six weeks in duration and training sessions were held from five to six days a week. The swimmers were divided into three groups. The first group consisted of males, aged sixteen to twenty-two. The second group was comprised of males, aged thirteen to eighteen. The final group was composed of females, aged thirteen to seventeen. The results of the study indicated no significant changes in mean PWC_{170} scores for any of the three groups of swimmers during the training season.

Roberts and Morgan (42) determined the relative effectiveness of various types of physical activity programs upon the physical working capacity of adult males. There were 140 subjects used in this study. The mean age was 39.14 years. The subjects were randomly assigned to a treadmill test (N=76) or to a bicycle ergometer test (N=64). The subjects volunteered to participate in one of eight exercise programs. These programs included three running groups, two cycling groups, two swimming groups, and one circuit training group. All exercise programs lasted for six weeks. It was found that the physical work capacity of relatively sedentary adult males can be significantly improved in six weeks. The results also revealed that utilization of the principle of the submaximal heart rate defined as 85 per cent of the predicted maximal heart rate is an effective method by which to accomplish this improvement (42). The degree of improvement was dependent upon the frequency of participation in the particular program and the nature of the activity. Running produced more improvement in physical work capacity than the non-weightbearing activities of swimming and cycling.

Tuttle (43) conducted a study to test the assumption that physical education majors should have higher work capacity than student nurses or a group chosen at random. Thirty-four physical education majors, sixty-five student nurses, and seventy-three individuals chosen at random comprised the sample for this study. All subjects were female. Each subject rode a bicycle ergometer for two minutes at maximum effort. Physical education majors, who participated in regular exercise, had a significantly higher physical work capacity than either of the other two groups. The mean maximum work rate of the physical education majors was 3076.5 kgm./min. In contrast, the mean maximum work rates of the student nurses and the random sample were 2722.3 and 2617.1 kgm./min., respectively. It was also found that a maximum effort of one minute is as good an indicator of work capacity as a maximum effort of two minutes. Maximum work rate was reached usually in fifteen seconds and was maintained for only a few seconds.

Adams <u>et al</u>. (36) studied the effects of training on work capacity in 196 Swedish school children. The subjects were ten to twelve years of age. Both city and country school children were involved in the study. The subjects were classified into three major training groups. The first group was designated as highly trained and consisted of children who were active in sports and received athletic awards, who had received a good gymnastic grade in school, or who performed heavy manual labor. The moderately trained group consisted of children who had an average gymnastic grade, or who walked or rode a bicycle over two kilometers to school each day. The final group was termed poorly trained and consisted of children who seldom took part in sports, who received no awards for sports, or who had a poor gymnastic mark in school. A Sjostrand Test was administered to the subjects in the late spring and early fall of the same year. The results indicated that working capacity was significantly greater with increasing degree of physical training.

Astrand (cited in 6) compared two groups of trained gymnasts and a group without gymnastic training. The group without gymnastic training had a physical working capacity thirty per cent lower than both the male and female gymnasts.

Sloan and Keen (44) studied the effect of training on the resting pulse rate of oarsmen and rugby players. The subjects were comprised of thirty-five oarsmen, forty-five rugby players, and twenty controls. Complete data was available on only fifty-eight of the original one-hundred subjects. The first test was held at the beginning of the academic year and then re-tested after a period of from two to four months.

During this period the rowing and rugby clubs had been training for their respective sports. There was no original significant difference in the resting pulse rates of the three groups. However, after the training periods, the oarsmen and rugby players had significantly lower pulse rates than did the control group.

Durnin et al. (45) investigated the effect of different severities of training during a ten-day period in forty-four male air force personnel. The subjects were divided into four groups. The first group acted as controls and did only the minimum of exercise necessary for everyday life. The other three groups walked ten kilometers, twenty kilometers, and thirty kilometers daily, respectively. The group of men who walked twenty kilometers daily showed the greatest increase in physical work capacity.

Holmgren et al. (46) conducted a PWC_{170} Test on hospital personnel, fifty-one males and thirty-six females, before and after various training periods. The training consisted of gymnastic exercises and running once or twice a week for several months or daily skiing in mountainous terrain for eight to ten days. Both the intermittent long-term training and the continuous short-term training were found to increase the mean PWC_{170} scores.

Nagle and Irwin (47) studied the effects of weight training on the physical work capacity of forty university freshmen, aged eighteen and nineteen. A control group of twenty subjects of the same age was also used. The weight training period was eight weeks in duration and all subjects were tested on submaximal and maximal exercise on the bicycle ergometer. The results indicated that no significant effect was produced by weight training on physical work capacity.

Brouha (48) has drawn several conclusions from research conducted on the effect of training on the cardiovascular system. Brouha states that the heart becomes more efficient with training and is able to circulate more blood even though it is beating less frequently. As training progresses, the heart rate becomes slower for a standard amount of work. The cardiovascular recovery processes are also said to improve with training. That is, the better trained the individual, the sooner his heart rate and blood pressure return to the pre-exercise level.

Jongbloed (49) observed two skaters and concluded that good training improved the circulatory function, the oxygen supply and the muscular function of the individuals.

Frick <u>et al</u>. (50) conducted a study on fourteen military service personnel, aged nineteen to twenty-six. All subjects were given a PWC_{170} Test before and after two months of basic training. After the training period, ten of the fourteen subjects had increased PWC_{170} scores, three subjects showed no change, and one subject decreased slightly. The subject who decreased in physical work capacity had a relatively high value initially. The mean increase in work capacity was twelve per cent and was significant at the .01 level.

Hall (51) states that a bradycardia effect, a slowing of the heart rate, appears with training. A physiological interpretation for this effect is given. This researcher feels that training results in hypertrophy of skeletal muscle, hypertrophy of the heart, increase in blood volume, and increased capillary development in skeletal muscle.

Cureton and Phillips (52) observed the changes in seventy measures of the heart and cardiovascular condition in middle-aged men after an eight week training period. The subjects were six males, aged twenty-eight to forty-seven. During the training period, workouts were held one hour per day, six days a week. The subjects' physical work capacity was tested once each month on a maximal treadmill test. A significant improvement in physical work capacity, at the .01 level, was found after the eight-week training period.

Thirteen world championship skaters were studied by Enschede and Jongbloed (53). The skaters participated in a six month training period and were examined three times during that period. Each subject performed two maximal tests at each testing session. The results indicated that oxygen capacity, maximum pulse frequency, maximum oxygen pulse, and maximum oxygen intake all markedly increased during the training period.

Faulkner (54) investigated the effect of cardiac conditioning on the anticipatory, exercise, and recovery heart rates of university freshmen and university athletes. Forty university athletes, participating on either the football, gymnastics, hockey or track teams, and twenty freshmen comprised the sample for the study. The athletes were tested before and after their respective season. The athletes had lower resting, anticipatory, and recovery heart rates than the non-athletes both initially and terminally. However, there was no significant differences between the athletes and non-athletes in terms of physical work capacity.

Watson (55) assessed the effects of a twenty-one week season of ice hockey on ten varsity hockey players, aged twenty to twenty-five. A group of ten undergraduate and graduate students, aged nineteen to twenty-eight, acted as the controls. All subjects were tested on a modified Sproule, Chapman maximal oxygen consumption test. Testing took place on three occasions: pre-season, mid-season, and end of season. The hockey players showed a significant increase in maximal oxygen consumption in terms of liters per minute between pre-season and end of season testing sessions. There was no significant difference between the control and experimental groups when maximal oxygen consumption was expressed in terms of ml/kg/min. No significant difference between the sub-maximal heart rates of the hockey group and control group could be attributed to the hockey training program.

Twenty varsity football players, aged nineteen to twenty-four, were tested during periods of pre-training, training, and de-training to investigate physiological changes which might occur during and following a season of football (56). The results indicated no significant differences in mean systolic blood pressure or mean pulse rate after exercise.

However, Hammer (56) concluded that the pulse rate measured after a standard form of exercise will become lower as an athlete continues to participate in a systematic training program.

Hanne (57) studied twenty-eight basketball players, thirteen young cyclists, and seventeen adult cyclists during preparation for their respective national championships. All subjects practised five to six times a week. A step test was administered and oxygen uptake and carbon dioxide emission values were obtained for each subject. Regular training was shown to favorably influence oxidizing and recuperative processes and the condition of the subjects in all groups. Hanson and Tabakin (58) compared the circulatory response to exercise in twenty-five normal men, aged twenty to twenty-nine, and nine male distance runners, aged eighteen to twenty-four. All subjects were studied while standing and recumbent at rest and while walking on a treadmill. They found that the heart rate at both rest positions and during all levels of exercise was lower in the distance runners. These differences became greater and more significant as the work loads increased. Tabakin et al. (59) revealed that these same distance runners showed a decrease in exercise heart rate after three months of training. The differences between pre-training and post-training exercise heart rate was not significant however.

Andrew et al. (60) studied the effects of training in athletes and non-athletes. Each subject served as his own control. The athlete group consisted of four university hockey players, aged nineteen to twenty-three, and the non-athlete group consisted of four male university freshmen, aged seventeen to nineteen. The hockey players trained from six to eight hours weekly for four months. The non-athletes engaged in a four week training program in which they spent an hour daily, five days per week, on running, bench-jumping, and rope-climbing exercises. All subjects were tested on a bicycle ergometer at three submaximal work loads. The work loads for the hockey players were 550 kpm/min., 750 kpm/min., and 900 kpm/min., respectively. The work loads for the non-athletes were 350 kpm/min., 550 kpm/min., and 750 kpm/min., respectively. Both before and after the respective training programs, the athletes had a lower mean minute volume, lower mean stroke volume at the two external work loads, and a lower mean heart rate at the higher work load. The hockey players significantly decreased their mean heart rate at the work load of 550 kpm/min. On the other hand, the mean heart rate of the non-athletes significantly decreased in the 350 and 550 kpm/min. work loads. Significant decreases in all cases occurred at the .05 level.

Cumming <u>et al</u>. (22) studied six boys and six girls, both aged thirteen to sixteen, during a six-day period of intensive training at a youth's track camp. All subjects were tested on a bicycle ergometer using the method of Wahlund (34) for submaximal results. The maximal load used was extrapolated from those results. Each subject was tested twice daily.

There was no change in the maximal oxygen uptake for either the boys or the girls during the six-day period. Submaximal pulse rates were seen to decrease six beats per minute for a constant work load. Maximal pulse rates decreased seven beats per minute for a constant work load. The results also indicated that submaximal pulse rates tended to decline during training before any increase in aerobic capacity occurred.

Karvonen and Barry (61) investigated the effects of a six-month training program on fifteen sedentary males, aged thirty-five to fifty-five. The training program was offered at noon six days per week and mean attendance was 3.4 times per week. A bicycle ergometer was used to test physical work capacity. The initial resistance on the bicycle ergometer was set at zero and was increased by 300 kpm/min. every two minutes. Each subject exercised until his heart rate reached 150 beats per minute. When the heart rate reached this level the test was terminated. As training progressed, the subjects were able to pedal for longer periods of time before reaching a heart rate of 150 beats per minute. The mean duration of the ride increased from 8.86 to 10.79 minutes. This value is significant at the .001 level. In addition, mean heart rates at standard work loads were at least ten beats per minute lower. This difference is significant at the .01 level.

Swenson and Zauner (62) conducted a study on ten sedentary males, aged thirty-six to fifty-six, in order to study the effects of physical conditioning on physical work capacity. The subjects participated in an eight week conditioning period which consisted of strength and flexibility-developing calisthenics, weight training, and running. Running was the major part of the program. Subjects were tested on a treadmill before, during, and two weeks after training. Physical work capacity was observed to increase significantly.

The effects of seasonal training on maximal cardiac output were studied by Douglas and Becklake (63) on four university hockey players. The subjects were tested before and after their four month training period. A bicycle ergometer was used to administer submaximal and maximal tests to the subjects. Each subject significantly increased his maximal work capacity over the training period. The researchers noted, however, that maximal heart rate and other values tested did not increase significantly. It was found that after training all subjects performed a given work load with less stress on circulation and respiration than before training. Therefore, a greater maximal work capacity was possible after training even though no increase in maximal circulatory capacity was evident (63).

Ekblom <u>et al</u>. (64) investigated the effects of sixteen weeks of training on the circulatory response to submaximal and maximal exercise in eight male subjects, aged nineteen to twenty-seven. The subjects were tested on a bicycle ergometer and it was shown that as a result of training the mean heart rate on the standard submaximal work load had decreased from 170 to 144 beats per minute. This difference is significant at the .05 level. The maximal oxygen uptake was found to be sixteen per cent higher than before training.

Hanson et al. (65) found that long-term physical training had significant effects on the physical work capacity of middle-aged men. The subjects for this study consisted of seven sedentary males, aged forty-six to fifty-one. Each subject was involved in a seven-month training program. Testing was done on a bicycle ergometer and on a treadmill. Results revealed that physical work capacity was markedly increased. There was also a significant difference in resting and exercise bradycardia.

Saltin et al. (66) studied the response to exercise after training in five male college students. The duration of the training period was from fifty-three to fifty-five days. This involved two workouts daily, Monday to Friday, and one on Saturday. Workouts consisted of both interval and continuous exercise. No difference was apparent in maximal oxygen uptake values after the training period but during submaximal exercise heart rate was ten to fifteen beats per minute lower for any standard work load.

Sinning and Adrian (67) studied work capacity changes in seven female intercollegiate basketball players after a two month season. Eight female subjects served as the control group. The basketball season consisted of twenty-five organized practises and seven games. Subjects were tested at the beginning and end of the season on a bicycle ergometer. Both maximal and submaximal exercise tests were administered. There was no significant change in submaximal values however, mean maximal oxygen uptake for the basketball group significantly increased from 34.4 to 38.8 ml/kg/min.

Six male elementary school students, age eleven, underwent a six-month training period which included seventeen sessions of interval training, thirteen sessions of dash training, nine sessions of distance training, five sessions of strength training, and nine sessions of ball games. Ekblom (68) administered two submaximal work tests on the bicycle ergometer to each subject before and after training. The submaximal tests were carried out at work loads of 300 and 450 kpm/min. Each work period had a six minute duration. Results indicated that at a work load of 300 kpm/min., the mean heart rate decreased from 129 to 122 beats per minute. At a work load of 450 kpm/min., the mean heart rate decreased from 147 to 139 beats per minute.

Fardy (69) studied eleven members of an intercollegiate soccer team to determine the effects of a ten-week program of training. The subjects were nineteen to twenty-one years of age. Five male undergraduate volunteers acted as the control group. Each subject was tested on four occasions: before training, after five weeks of training, after ten weeks of training, and after five weeks of detraining. A bicycle ergometer was used for testing. All subjects were tested at rest, during and at 1½ minutes following a submaximal ride, and during and at two, five, ten, and fifteen minutes of a maximal ride. The results indicated that changes in cardiac and metabolic measures are more evident during work than at rest. The ten-week training program revealed significant increases in ventilation and oxygen intake measures. These increases were significant at the .05 level. It should be noted that most of the fitness improvements were made during the first five weeks of the program.

Pollock et al. (70) compared the training effects of a two day per week program as opposed to a four day per week program. The subjects were nineteen male volunteers, aged twenty-eight to thirty-nine. The mean age was 32.5 years. Eight sedentary males formed the control group. The subjects in the experimental group were divided into two sub-groups. One group exercised two days per week for twenty weeks and the other group exercised four days per week for twenty weeks. Each exercise session consisted of thirty minutes of continuous walking, jogging, or running. A treadmill test was administered to all subjects. Both exercise groups improved significantly in physical work capacity and cardiovascular fitness. However, the four days per week group showed a greater improvement in work capacity and cardiovascular fitness than did the two days per week group. It was also shown that the majority of between group training effects occurred during the latter weeks of the training program. Therefore, a conclusion was drawn that maximum or optimal training effects occur after many weeks of training.

Faria (71) studied the effects of training to heart rates of 120 to 130, 140 to 150, and 160 to 170 beats per minute on physical work capacity. Forty male college students served as subjects. The subjects were divided into three training groups and one control group. The training program consisted of bench stepping until the assigned heart rate was elicited, five days per week for four weeks. The results supported the hypothesis that the severity of the training effort is related to, but not proportional to, intensity of training when training to improve physical work capacity (71).

Sharkey (38) conducted a study on thirty-six male college students in which the subjects were assigned to train at one of three levels of work intensity and one of two levels of work duration. The three levels of work intensity included training at heart rates of 130, 150, and 170 beats per minute. The two levels of work duration were specified in total kilopond meters of work performed. The two levels were 750 and 1,500 kpm/min. As a result, six different training programs were studied. Each program consisted of riding a bicycle ergometer at the specified intensity and duration three days per week for six weeks. All subjects were administered three tests before and after the six week training program. The tests included the Astrand-Rhyming step test prediction of maximal oxygen intake (4), the Balke treadmill test (cited in 55), and the Sjostrand physical work capacity test (8). The results revealed no pre-post training differences between intensity, duration, or interaction of any of the six training programs.

Steadward (37) studied the effects of a three-month jogging program on the heart rate, blood pressure, vital capacity, body fat, and physical work capacity of seventy-nine males, aged twenty to 50-plus. The mean PWC_{170} increase was 8.85 per cent. The mean PWC_{170} per kg. of body weight improved 9.91 per cent and the mean PWC_{170} per kg. of lean body weight increased 8.79 per cent. It was also shown that mean PWC_{170} improvement increased more significantly with age.

Nagle and Pellegrino (72) investigated the changes in maximal oxygen uptake in six high school runners, aged fourteen to seventeen, over a competitive track season. The training period was of seven to eight weeks duration. Subjects were tested, before and after the training period, on a treadmill. The results indicated that each runner increased his aerobic power in excess of 200 ml/min. The range was from 215 to 288 ml/min.

Holmer and Astrand (73) examined the oxygen uptake of female identical twins. One of the twins was receiving special swimming training at the time. The girls were tested in swimming, running, and bicycling situations. The girl trained in swimming reached higher oxygen uptake values than her twin sister in all of the exercises with the exception of running uphill at a grade of three degrees.

Massicotte (74) studied the relative effects of three intensities of training upon the cardiorespiratory fitness of children. The subjects were thirty-six boys, aged eleven to thirteen. The subjects were divided into four groups. Three groups trained at heart rates of 130 to 140, 150 to 160, and 170 to 180 beats per minute, respectively. The fourth group acted as a control. Each of the three experimental groups trained on a bicycle ergometer three times per week for six weeks. Each training session was of twelve minutes duration. All subjects were tested on the bicycle ergometer before and after the six week program. There were significant decreases in heart rate for the three training groups at submaximal work loads. However, no significant differences occurred between the three training groups.

IV. PHYSICAL WORK CAPACITY AND AGE

The literature generally agrees that physical work capacity steadily increases with age to a certain point. Then a levelling off occurs and physical work capacity declines (3, 6,24,36,37,75,76,77,78).

In Howell and Macnab's study (14), which examined a cross section of Canadian children, the results indicated that a continuous increase in mean PWC_{170} for each age group from seven to seventeen occurred in the male sample. In the female sample however, this continuous increase ceases at the age of thirteen and a levelling occurs.

Astrand and Rodahl (3) state that the mean value for heart rate at a given submaximal oxygen uptake is the same for individuals of the same sex and state of training regardless of age. They feel that this applies from the ages of twenty-five to at least seventy.

V. PHYSICAL WORK CAPACITY AND SEX

Research indicates that males usually have higher physical work capacity values than do females (12,14,36,75,76,77, 79).

Astrand and Rodahl (3) state that before puberty there is no significant difference in maximal aerobic power between males and females. However, after puberty, the male's maximal aerobic power is seen to be twenty-five to thirty per cent higher than that of the female's. On the average, the maximal oxygen uptake for a sixty-five-year-old male is the same for a twenty-five-year-old female.

Bengtsson (6) has found no significant differences in work capacity between males and females up to the age of fifteen.

VI. PHYSICAL WORK CAPACITY AND BODY WEIGHT

Physical work capacity appears to increase with increased weight (36,75,77).

Howell and Macnab (74) found that correlation coefficients between body weight and PWC_{170}, for each age group, ranged from r = .23 to r = .60 for males. The correlation coefficient for the female age groups ranged from r = .21 to r = .51.

Taylor (80) concluded that during submaximal exercise, oxygen uptake was primarily a function of body weight. This relationship decreased sharply during maximal work.

VII. PHYSICAL WORK CAPACITY AND BODY HEIGHT

Adams et al. (36,75) state that work capacity has a tendency to increase with increased height.

Cumming and Cumming (77) studied Winnipeg children and found that correlations between PWC_{170} and body height were r = .865 for boys and r = .658 for girls.

VIII. PHYSICAL WORK CAPACITY AND PERFORMANCE

Newman (35) studied twenty-five male and fourteen female swimmers over a season of training. Physical work capacity scores and performance times were recorded for each subject. The results indicated no significant changes in either mean PWC_{170} scores or mean performance times over the course of the swimming season.

IX. PHYSICAL WORK CAPACITY AND MOTIVATION

Taylor (80) states that motivation has a minimal effect on physical work capacity provided the work test which is administered is simple and standard.

Wilmore (81) conducted a study on twenty-two male college students in which the physical work capacity of each subject was assessed under two control conditions and one experimental condition. The subjects were motivated by a competitive situation in the experimental condition. A bicycle ergometer was used to assess physical work capacity.

There were no significant differences in physical work capacity scores between the three conditions.

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CHAPTER III

METHODS AND PROCEDURE

I. SUBJECTS

The sample used for this study consisted of twenty-six intercollegiate football players from the University of Alberta. The subjects were volunteers, between the ages of eighteen to twenty-four inclusive. The mean age was 20.5 years.

II. EXPERIMENTAL PROCEDURE

The duration of the study was twelve weeks. This included one week prior to the pre-season period, a two week pre-season period, and a nine week regular season period.

The first testing session occurred during the five days immediately prior to the start of the pre-season period. The second testing session was held immediately after the completion of the two week pre-season period. The third and final testing session was held during the last five days of the regular season period. Complete data had been obtained on all the subjects at least one day before the football team's final league game.

The subjects were neither tested in a particular order nor at a particular time of the day during any of the testing sessions.

III. ANTHROPOMETRIC DATA

Prior to each testing session, the following anthropometric data was collected from each subject: age (years and months), height (inches), and weight (pounds). This information was recorded on a specifically designed data sheet (Appendix D).

IV. EQUIPMENT

The ergometer used in this study was a Von Dobeln bicycle, manufactured by the Monark Company Limited of Sweden. The wheel of the ergometer was braked mechanically by a friction belt. The amount of resistance offered by the friction belt was regulated by a sinus balance, scale, and tension regulating mechanism on the bicycle ergometer. The sinus balance of the bicycle ergometer was calibrated before each testing session. The method of calibration was identical to that stated by Howell and Macnab (1). The height of the seat could be adjusted to individual preference.

An electrical counter recorded the number of revolutions pedalled. The counter was connected to a microswitch which in turn was attached to the pedal axis.

An electrical metronome was used to assist the subject in maintaining a pedalling rate as close to sixty complete revolutions per minute as possible. Therefore, the metronome was set to 120 beats per minute.

A Sanborn 500 Visocardiette Recorder was used to record heart beat. Heart beat was recorded from two chest electrodes and one reference electrode. The chest electrodes fitted at the first intercostal space directly below each nipple and below the pectoralis major muscle while the reference electrode fitted below the subject's right scapula (1).

A stopwatch was used to time the twelve minute test. In order to standardize instructions, a tape recorder was used to introduce each subject to the test.

A weigh scale with a height-measuring device was used to obtain the height and weight of each subject.

A heart rate conversion sheet (Appendix F) was used to convert the heart-beats, as recorded by the electrocardiogram, to heart rate per minute.

V. TEST PROCEDURE FOR THE DETERMINATION OF PWC_{170}

All subjects were requested to wear gym strip, shorts or sweat pants and running shoes, to each testing session.

Upon entering the laboratory, the required anthropometric data (height, weight, and age) was obtained for each subject. The subject sat on the bicycle ergometer and the height of the seat was adjusted so that the knee was slightly bent when the lower pedal was resting directly below the longitudinal arch of the foot (1). The subject then listened to a tape recorded set of instructions related to the test procedures (Appendix E). While listening to these instructions, the electrocardiograph leads were connected to the subject by the tester. After the instructions were heard, any questions the subject had regarding the performance of the test were answered.

The subject's resting heart rate was then calculated. The method of calculating heart rate, throughout this study, involved determining the distance of three heart-beats, as recorded by the electrocardiogram, and then converting this distance into heart rate per minute by means of the heart rate conversion sheet. The test, as such, was not started until the resting heart rate was 100 beats per minute or less.

Once the resting heart rate was at an acceptable level, the electric metronome was turned on and the subject was asked to start pedalling at a rate of sixty revolutions per minute. The subject was encouraged to keep in time with the sounds emitted by the metronome. The subject was allowed to adjust to the pace with no work load. When the pace was achieved, the initial work load was set and the electric counter and stopwatch were started simultaneously.

The test consisted of riding the bicycle ergometer for twelve consecutive minutes, four minutes at each of three progressively heavier work loads. The heart rate and pedal revolutions were recorded within the last five seconds of the fourth, eighth, and twelfth minutes of exercise. At the end of the fourth and eighth minutes of exercise the work load was increased. The initial work load (1.5 kp. for all subjects) was set to elicit a desired heart rate of 115 to 130 beats per minute, after four minutes of exercise. The second work load had a desired heart rate response of 130 to 145 beats per minute, after eight minutes of exercise. The third and final work load had a desired heart rate response of 160 to 180 beats per minute, after twelve minutes of exercise. The subject was not allowed to stop at any time during the twelve minute testing session.

VI. THE FOOTBALL TEAM'S PRACTICE AND GAME SCHEDULE

The subjects of this study were members of the 1973 University of Alberta intercollegiate football team. This team had an eleven week season which included a two week pre-season period and a nine week regular season period.

The first week of the pre-season period consisted of two practices a day. The remaining ten weeks of the season consisted of one practice a day, Monday through Friday, with a game on Saturday. On occasion, Sunday practices were also held. The team's weekly practice schedule is included in Appendix G.

VII. CONDITIONS OF TESTING

All subjects were tested in a Physical Education Laboratory in the Physical Education Building at the University of Alberta.

There was no attempt to control or record the temperature, humidity, or barometric pressure of the testing laboratory.

VIII. STATISTICAL ANALYSIS

The raw data obtained during the testing sessions was converted into PWC_{170} and PWC_{170}/kg. values by the use of an APL program (Appendix A) in conjunction with an IBM 360/67 computer.

The PWC_{170} and PWC_{170}/kg. scores, for the football and control groups, were treated to determine whether significant differences occurred throughout the eleven-week training period.

A two way analysis of variance with repeated measures was used to treat the data. A FORTRAN program was used to compute the analysis of variance.

Where significant differences within groups were indicated by the analysis of variance, a Scheffe Test (2) was used to determine between which testing sessions these differences occurred. Significant differences between groups at one testing session were determined by the use of a Scheffe Test (2).

In addition, the football data was analyzed by position. A two way analysis of variance with repeated measures was also used to treat these physical work capacity scores. When the analysis of variance indicated significant differences within or between positions, a Scheffe Test was used to determine where the differences occurred.

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CHAPTER IV

RESULTS AND DISCUSSION

The purpose of the study was to compare the physical work capacity, as measured by a modified Sjostrand PWC_{170} test, of intercollegiate football players at three times during the course of a season. The players were tested at the beginning of pre-season training (Test I), at the end of preseason training (Test II) and at the end of the regular season (Test III).

Data was obtained on fifty-five football players during the first testing session. Throughout the season, twenty-three subjects left the team and six subjects were injured while playing. Therefore, complete data was obtained on twenty-six intercollegiate football players. Nineteen first-year university physical education students volunteered to serve as control subjects.

In this chapter the results are presented by group and by position. The former refers to the football players, as a group, and to the control subjects, as a group. The latter refers to the football players in terms of the primary position played. Four positions have been defined: (1) offensive linemen, (2) offensive backs, (3) defensive linemen and (4) defensive backs.

Any significant differences which are stated in the results occur at the .05 level.

I. ANTHROPOMETRIC DATA OF THE GROUPS

The mean age, height, and weight of the football and control groups are presented in Tables I and II (pp. 59, 60). The mean age and height reported are those values obtained during the first testing session. The mean weight values are those recorded at each of the three testing sessions. Anthropometric data for each subject is presented in Appendix B.

The football players, as a group, were older, taller, and heavier than the controls. As the literature (1,2,3,4, 5,6) indicates, these age, height, and weight factors are important when comparing the physical work capacity of individuals and/or groups.

II. COMPARISONS WITHIN AND BETWEEN GROUPS

A two way analysis of variance with repeated measures (7) was used to treat the football and control group physical work capacity scores. Table III (p. 61) summarizes the analysis of the PWC_{170} scores for the two groups. Significant differences occurred within and between groups. The PWC_{170}/kg. score analysis appears in Table IV (p. 61) and significant differences were noted within groups but not between groups. Tables III and IV (p. 61) do not contain all the information that was provided by the IBM 360/67 computer.

TABLE I

MEANS AND RANGES FOR AGE, HEIGHT AND WEIGHT, FOR FOOTBALL PLAYERS N=26

Statistic	Unit	Time of Measurement	Mean	Range
Age	Years	Beginning of Pre-Season	20.51	18.0 - 24.16
Height	Inches	Beginning of Pre-Season	71.38	67.0 - 75.0
Weight	Pounds	Beginning of Pre-Season	192.57	152.0 - 245.0
	Kilograms	Beginning of Pre-Season	87.53	69.09 - 111.36
Weight	Pounds	End of Pre-Season	191.57	151.0 - 243.0
	Kilograms	End of Pre-Season	87.07	68.63 - 110.45
Weight	Pounds	End of Regular Season	191.03	149.0 - 245.0
	Kilograms	End of Regular Season	86.83	67.72 - 111.36

TABLE II

MEANS AND RANGES FOR AGE, HEIGHT AND WEIGHT, FOR CONTROL SUBJECTS N=19

Statistic	Unit	Time of Measurement	Mean	Range
Age	Years	Beginning of Pre-Season	19.59	17.5 - 33.0
Height	Inches	Beginning of Pre-Season	68.47	63.0 - 74.0
Weight	Pounds	Beginning of Pre-Season	146.57	119.0 - 205.0
	Kilograms	Beginning of Pre-Season	66.62	54.09 - 93.18
Weight	Pounds	End of Pre-Season	147.0	117.0 - 204.0
	Kilograms	End of Pre-Season	66.81	53.18 - 92.72
Weight	Pounds	End of Regular Season	147.57	118.0 - 205.0
	Kilograms	End of Regular Season	67.07	53.63 - 93.18

TABLE III

TWO WAY ANALYSIS OF VARIANCE WITH REPEATED MEASURES OF THE SJOSTRAND PWC_{170} TEST MEANS MEASURED AT THREE TIMES DURING THE TRAINING SEASON FOOTBALL PLAYERS, N=26, CONTROL GROUP, N=19

Source of Variation	Sum of Squares	df	Mean Square	F	P
Between Groups	3,666,030	1	3,666,030	29.46	<.001
Within Groups	288,540	2	144,270	6.45	.002
Interaction	1,923,670	2	91,740	4.10	.01

TABLE IV

TWO WAY ANALYSIS OF VARIANCE WITH REPEATED MEASURES OF THE SJOSTRAND PWC_{170}/kg. TEST MEANS MEASURED AT THREE TIMES DURING THE TRAINING SEASON FOOTBALL PLAYERS, N=26, CONTROL GROUP, N=19

Source of Variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.102	1	0.10	.004	.94
Within Groups	60.748	2	30.37	8.73	<.001
Interaction	24.545	2	12.27	3.52	.03

The mean PWC_{170} and PWC_{170}/kg. values for both groups appear in Tables V and VI (p. 62), respectively.

TABLE V

PWC_{170} GROUP MEANS MEASURED AT THREE TIMES DURING THE TRAINING SEASON

	Test I	Test II	Test III
Football N=26	1341	1490	1395
Control N=19	1010	1063	1151

TABLE VI

PWC_{170}/kg. GROUP MEANS MEASURED AT THREE TIMES DURING THE TRAINING SEASON

	Test I	Test II	Test III
Football N=26	15.49	17.22	16.36
Control N=19	15.25	16.20	17.43

DIFFERENCES WITHIN THE FOOTBALL GROUP

A Scheffe Test was used to compare football group means from one testing session to another. Table VII (p. 63) outlines the Scheffe Test results for mean PWC_{170} scores and Table VIII (p. 64) outlines the results for mean PWC_{170}/kg. scores.

TABLE VII

SCHEFFE TEST FOR BETWEEN TEST PWC_{170} MEANS FOR THE FOOTBALL PLAYERS

Test I	Test II	Test III	Mean Difference	Critical F	Calculated F
1341		1395	54 NS	6.22	1.71
1341	1490		149*	6.22	13.05
	1490	1395	95 NS	6.22	5.30

* Significant at the .05 level.
NS Not significant at the .05 level.

It can be seen from Table VII (p. 63) that the difference between the beginning of pre-season and end of pre-season mean PWC_{170} scores for the football players was significant. Differences in mean PWC_{170} scores for the other two comparisons were not significant.

The mean PWC_{170}/kg. scores were also found to be significantly different between the beginning of pre-season and end

TABLE VIII

SCHEFFE TEST FOR BETWEEN TEST PWC_{170}/kg. MEANS FOR THE FOOTBALL PLAYERS

Test I	Test II	Test III	Mean Difference	Critical F	Calculated F
15.49		16.36	.87 NS	6.22	2.86
15.49	17.22		1.73*	6.22	11.33
	17.22	16.36	.86 NS	6.22	2.79

* Significant at the .05 level.
NS Not significant at the .05 level.

of pre-season tests. Differences between the two other mean PWC_{170}/kg. comparisons were not significant.

These results indicate that the only significant differences in mean PWC_{170} and PWC_{170}/kg. scores, for the football players, occurred during the fourteen-day pre-season period. No significant differences appeared between the beginning and end of the nine-week regular season period or between the eleven weeks from the beginning of the pre-season to the end of the regular season. As can be seen from Figures I and II (pp. 65, 66), there is a very rapid increase in mean PWC_{170} and PWC_{170}/kg. values between the first and second testing sessions. Then a gradual decline appears between the second and third testing sessions. It can be assumed therefore that a relatively high emphasis was placed on physical conditioning

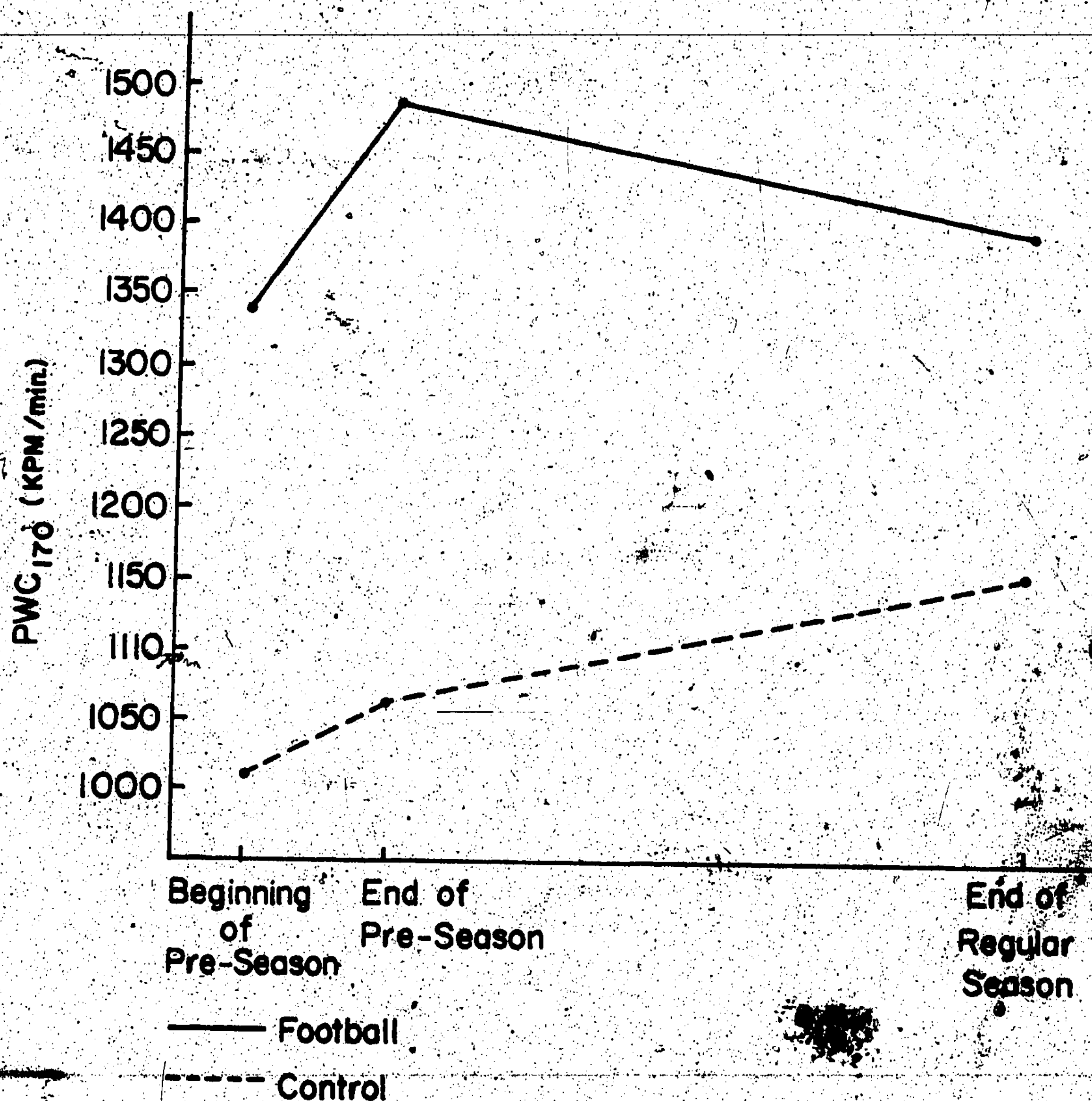

FIGURE I

CHANGES IN MEAN PWC_{170} SCORES DURING THREE TESTING SESSIONS FOR THE FOOTBALL AND CONTROL GROUPS

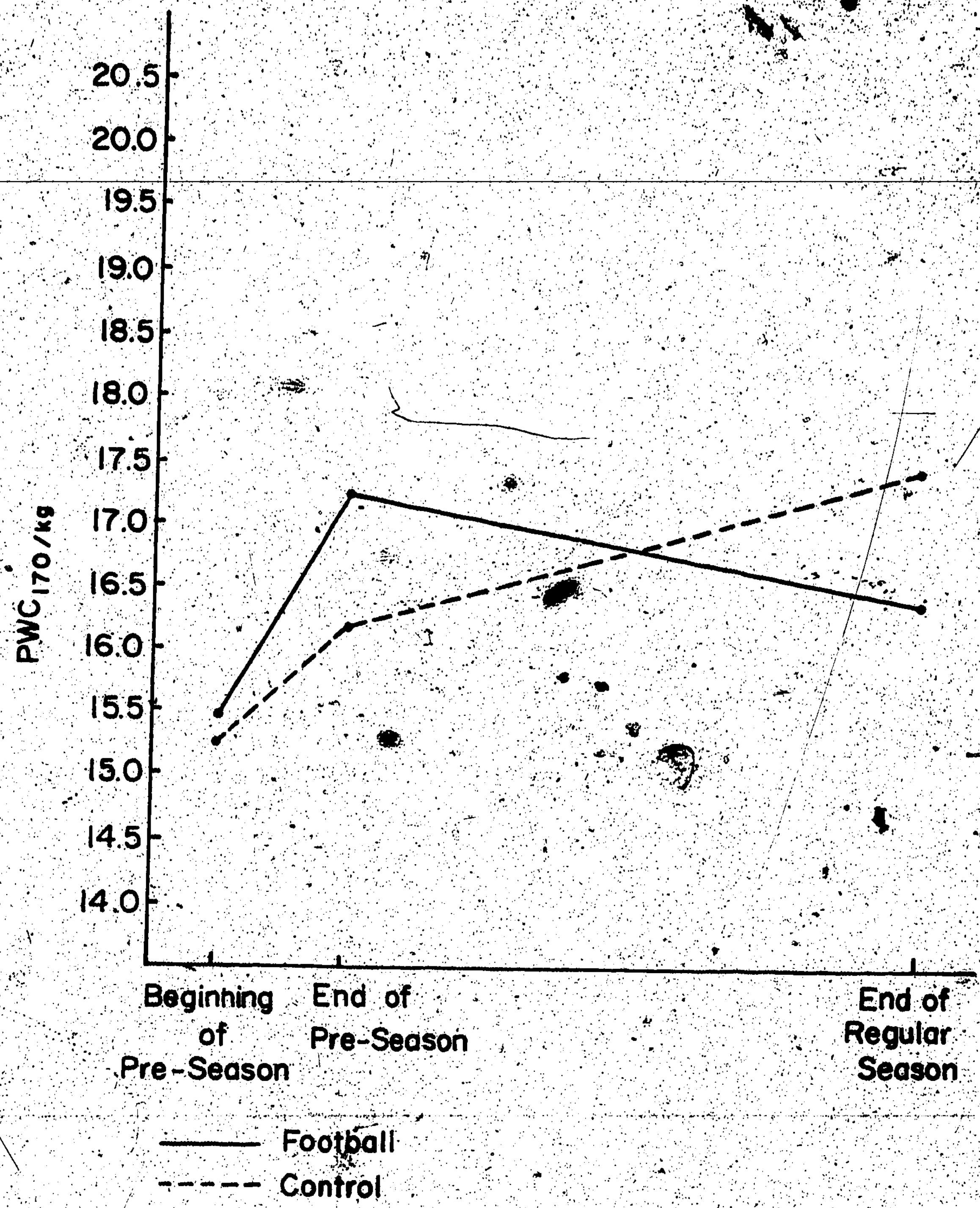

FIGURE II

CHANGES IN MEAN PWC_{170}/kg. SCORES DURING THREE TESTING SESSIONS FOR THE FOOTBALL AND CONTROL GROUPS.

during the pre-season period. This emphasis decreased during the regular season. It would seem that this is a logical assumption because a pre-season period for a football team is usually a time in which the players are working towards achieving playing condition. However, once the season starts the emphasis has a tendency to shift from conditioning to individual and team play execution. The majority of the regular season practice schedule concentrates on team offensive and defensive skills. The physical conditioning of the players, as such, is usually confined to a relatively few minutes in the latter stages of the practice. This is exemplified in the football teams' weekly practice schedule (Appendix G).

DIFFERENCES WITHIN THE CONTROL GROUP

The means for the control subjects were compared by the use of a Scheffe Test. Within the control group, significant differences were evident between the first and third testing sessions for both mean PWC_{170} and PWC_{170}/kg. values. These outcomes are summarized in Tables IX and X (pp. 58).

Figures I and II (pp. 65, 66) illustrate that the control group steadily increased in mean PWC_{170} and PWC_{170}/kg. scores from the first testing session to the third.

Results of this nature might have been anticipated due to the type of control subjects used. All controls were university physical education students who participated in a variety of activity courses each week. No significant differ-

TABLE IX

SCHEFFE TEST FOR BETWEEN TEST PWC_{170}

MEANS FOR THE CONTROL GROUP

Test I	Test II	Test III	Mean Difference	Critical F	Calculated F
1010		1151	141*	6.22	8.91
1010	1063		53 NS	6.22	1.25
	1063	1151	88 NS	6.22	3.47

* Significant at the .05 level.
NS Not significant at the .05 level.

TABLE X

SCHEFFE TEST FOR BETWEEN TEST PWC_{170}/kg.

MEANS FOR THE CONTROL GROUP

Test I	Test II	Test III	Mean Difference	Critical F	Calculated F
15.25		17.43	2.18*	6.22	13.01
15.25	16.20		.95 NS	6.22	2.47
	16.20	17.43	1.23 NS	6.22	4.14

* Significant at the .05 level.
NS Not significant at the .05 level.

ences in mean PWC_{170} or PWC_{170}/kg. values between Test I and Test II were expected because the controls were not attending classes during that time.

The steady increase in the control group mean physical work capacity scores may also have been a result of improvement with repeated testing. Zahar (8) states that improvement of physical work capacity scores occurs with repeated testing of the same subjects.

DIFFERENCES BETWEEN GROUPS

A Scheffe Test was used to compare group means at each of the three testing sessions. Tables XI, XII and XIII (p. 70) summarize the comparisons of mean PWC_{170} values between the football and control groups at Tests I, II and III, respectively. There are significant differences between mean football PWC_{170} and mean control PWC_{170} values at each of the three testing sessions.

Comparisons of mean PWC_{170}/kg. values between the groups at all testing sessions are summarized in Tables XIV, XV and XVI (p. 71). No significant differences between mean football PWC_{170}/kg. and mean control PWC_{170}/kg. values occurred at any of the testing sessions.

As previously stated, the mean weight of the football players was greater than that of the controls at each testing session. Therefore it would be expected that the football players would have higher mean PWC_{170} values than the controls (1,2,5,6). The most relevant comparison between the groups

TABLE XI

SCHEFFE TEST FOR BETWEEN GROUP PWC_{170} MEANS ON TEST I

Football	Control	Mean Difference	Critical F	Calculated F
1341	1010	331*	3.92	21.32

* Significant at the .05 level.

TABLE XII

SCHEFFE TEST FOR BETWEEN GROUP PWC_{170} MEANS ON TEST II

Football	Control	Mean Difference	Critical F	Calculated F
1490	1063	427*	3.92	35.49

* Significant at the .05 level.

TABLE XIII

SCHEFFE TEST FOR BETWEEN GROUP PWC_{170} MEANS ON TEST III

Football	Control	Mean Difference	Critical F	Calculated F
1395	1151	244*	3.92	11.58

* Significant at the .05 level.

TABLE XIV

SCHEFFE TEST FOR BETWEEN GROUP PWC_{170}/kg. MEANS ON TEST I

Football	Control	Mean Difference	Critical F	Calculated F
15.49	15.25	.24 NS	3.92	.06

NS Not significant at the .05 level.

TABLE XV

SCHEFFE TEST FOR BETWEEN GROUP PWC_{170}/kg. MEANS ON TEST II

Football	Control	Mean Difference	Critical F	Calculated F
17.22	16.20	1.02 NS	3.92	1.10

NS Not significant at the .05 level.

TABLE XVI

SCHEFFE TEST FOR BETWEEN GROUP PWC_{170}/kg. MEANS ON TEST III

Football	Control	Mean Difference	Critical F	Calculated F
16.36	17.43	1.07 NS	3.92	1.21

NS Not significant at the .05 level.

is made with mean PWC_{170}/kg. values because body weight is taken into consideration. When this type of comparison is made the football players do not differ significantly from the controls.

III. ANTHROPOMETRIC DATA BY POSITION

The mean age, height, and weight of the football players, by position are outlined in Tables XVII, XVIII, XIX and XX (pp. 73, 74, 75, 76). The mean age and height values are those obtained during the first testing session. The mean weight values are those recorded at each of the three testing sessions.

The mean age by position was similar in all instances. Mean height values reveal that the defensive backs were the shortest of all four positions. When mean weight values are considered, both offensive and defensive linemen are heavier than either offensive or defensive backs. The offensive linemen have the largest mean weight values at each testing session. The defensive linemen are second in terms of this measurement, followed by offensive backs and then defensive backs.

IV. COMPARISONS WITHIN AND BETWEEN POSITIONS

An analysis of variance was used to treat the physical work capacity scores by position. The number of players in each position was not equal. There were six offensive linemen, seven offensive backs, eight defensive linemen and five

TABLE XVII

MEANS AND RANGES FOR AGE, HEIGHT AND WEIGHT, FOR OFFENSIVE LINEMEN N=6

Statistic	Unit	Time of Measurement	Mean	Range
Age	Years	Beginning of Pre-Season	20.46	19.08 - 22.41
Height	Inches	Beginning of Pre-Season	72.33	68.0 - 74.0
Weight	Pounds	Beginning of Pre-Season	217.33	195.0 - 245.0
	Kilograms	Beginning of Pre-Season	98.78	88.63 - 111.36
Weight	Pounds	End of Pre-Season	215.0	195.0 - 243.0
	Kilograms	End of Pre-Season	97.72	88.63 - 110.45
Weight	Pounds	End of Regular Season	214.0	193.0 - 245.0
	Kilograms	End of Regular Season	97.27	87.72 - 111.36

TABLE XVIII

MEANS [illegible] RANGES FOR AGE, HEIGHT AND WEIGHT, FOR OFFENSIVE BACKS N=7

Statistic	Unit	Time of Measurement	Mean	Range
Age	Years	Beginning of Pre-Season	20.46	18.0 - 23.0
Height	Inches	Beginning of Pre-Season	71.42	70.0 - 73.0
Weight	Pounds	Beginning of Pre-Season	181.57	165.0 - 210.0
	Kilograms	Beginning of Pre-Season	82.53	75.0 - 95.45
Weight	Pounds	End of Pre-Season	181.14	165.0 - 209.0
	Kilograms	End of Pre-Season	82.33	75.0 - [illegible].0
Weight	Pounds	End of Regular Season	181.57	166.0 - 210.0
	Kilograms	End of Regular Season	82.53	75.45 - 96.45

TABLE XXIX

MEANS AND RANGES FOR AGE, HEIGHT AND WEIGHT, FOR DEFENSIVE LINEMEN N=8)

Statistic	Unit	Time of Measurement	Mean	Range
Age	Years	Beginning of Pre-Season	21.17	18.16 - 24.16
Height	Inches	Beginning of Pre-Season	72.5	68.0 - 75.0
Weight	Pounds	Beginning of Pre-Season	204.37	177.0 - 242.0
	Kilograms	Beginning of Pre-Season	92.89	[illegible]0.45 - 110.0
Weight	Pounds	End of Pre-Season	204.5	176.0 - 237.0
	Kilograms	End of Pre-Season	92.95	80.0 - 107.72
Weight	Pounds	End of Regular Season	203.0	172.0 - 234.0
	Kilograms	End of Regular Season	92.27	78.18 - 106.36

TABLE XX

MEANS AND RANGES FOR AGE, HEIGHT AND WEIGHT, FOR DEFENSIVE BACKS N=5

Statistic	Unit	Time of Measurement	Mean	Range
Age	Years	Beginning of Pre-Season	21.16	18.16 - 24.0
Height	Inches	Beginning of Pre-Season	68.4	68.0 - 70.0
Weight	Pounds	Beginning of Pre-Season	159.4	152.0 - 175.0
	Kilograms	Beginning of Pre-Season	72.45	69.09 - 79.54
Weight	Pounds	End of Pre-Season	159.4	151.0 - [illegible].0
	Kilograms	End of Pre-Season	72.45	68.63 - 78.63
Weight	Pounds	End of Regular Season	157.6	149.0 - 170.0
	Kilograms	End of Regular Season	71.63	67.72 - 77.27

defensive backs.

Table XXI (p. 77) summarizes the analysis of the PWC_{170} scores by position. Significant differences were found within positions from one test to another. No significant differences were found between positions at either of the three testing sessions.

TABLE XXI

TWO WAY ANALYSIS OF VARIANCE WITH REPEATED MEASURES OF THE SJOSTRAND PWC_{170} TEST MEANS, BY POSITION, MEASURED AT THREE TIMES DURING THE TRAINING SEASON OFFENSIVE LINEMEN, N=6, OFFENSIVE BACKS, N=7, DEFENSIVE LINEMEN, N=8, DEFENSIVE BACKS, N=5

Source of Variation	Sum of Squares	df	Mean Squares	[illegible]	P
Between Positions	409,330	3	[illegible]	[illegible]	[illegible]
Within Positions	243,150	2	121,58[illegible]	[illegible]	[illegible]
Interaction	229,320	6	38,220	[illegible]	0.23

The analysis of PWC_{170}/kg. scores by position is covered in Table XXII (p. 78). Significant differences were found within but not between positions, as in Table XXI (p. 77).

The mean PWC_{170} and PWC_{170}/kg. scores for each position at each test are presented in Tables XXIII and XXIV (p. 79).

TABLE XXII

TWO WAY ANALYSIS OF VARIANCE WITH REPEATED MEASURES OF THE SJOSTRAND PWC_{170}/kg. TEST MEANS, BY POSITION, MEASURED AT THREE TIMES DURING THE TRAINING SEASON OFFENSIVE LINEMEN, N=6, OFFENSIVE BACKS, N=7, DEFENSIVE LINEMEN, N=8, DEFENSIVE BACKS, N=5

Source of Variation	Sum of Squares	df	Mean Square	F	P
Between Positions	98.447	3	32.81	1.28	0.30
Within Positions	34.010	2	17.00	4.99	0.01
Interaction	35.021	6	5.83	1.71	0.14

DIFFERENCES WITHIN EACH POSITION

Comparisons of physical work capacity mean scores from test to test within each position was done by the use of a Scheffe Test.

Tables XXV and XXVI (p. 80) reveal that there were no significant differences in mean PWC_{170} or PWC_{170}/kg. scores for the offensive linemen between any of the three tests.

No significant differences in mean PWC_{170} or PWC_{170}/kg. scores for offensive backs appeared between any of the three tests. Tables XXVII and XXVIII (p. 81) summarizes the comparisons.

Tables XXIX and XXX (pp. 82, 83) indicate significant differences in mean PWC_{170} and PWC_{170}/kg. scores between the beginning of pre-season and end of pre-season tests for

TABLE XXIII

PWC_{170} FOOTBALL MEANS BY POSITION MEASURED AT THREE TIMES DURING THE TRAINING SEASON

	Test I	Test II	Test III
Offensive Linemen N=6	1421	1604	1372
Offensive Backs N=7	1287	1414	1306
Defensive Linemen N=8	1369	1596	1486
Defensive Backs N=5	1273	1288	1402

TABLE XXIV

PWC_{170}/kg. FOOTBALL MEANS BY POSITION MEASURED AT THREE TIMES DURING THE TRAINING SEASON

	Test I	Test II	Test III
Offensive Linemen N=6	14.61	16.77	14.35
Offensive Backs N=7	15.49	17.03	15.86
Defensive Linemen N=8	14.81	17.50	16.24
Defensive Backs N=5	17.61	17.78	19.63

TABLE XXV

SCHEFFE TEST FOR BETWEEN TEST PWC_{170}

MEANS FOR OFFENSIVE LINEMEN

Test I	Test II	Test III	Mean Difference	Critical F	Calculated F
1421		1372	49 NS	6.42	.26
1421	1604		183 NS	6.42	3.71
	1604	1372	232 NS	6.42	5.96

NS Not significant at the .05 level.

TABLE XXVI

SCHEFFE TEST FOR BETWEEN TEST PWC_{170}/kg.

MEANS FOR OFFENSIVE LINEMEN

Test I	Test II	Test III	Mean Difference	Critical F	Calculated F
14.61		14.35	.26 NS	6.42	.05
14.61	16.77		2.16 NS	6.42	4.13
	16.77	14.35	2.42 NS	6.42	5.18

NS Not significant at the .05 level.

TABLE XXVII

SCHEFFE TEST FOR BETWEEN TEST PWC_{170}

MEANS FOR OFFENSIVE BACKS

Test I	Test II	Test III	Mean Difference	Critical F	Calculated F
1287		1306	19 NS	6.42	.04
1287	1414		127 NS	6.42	2.09
	1414	1306	108 NS	6.42	1.51

NS Not significant at the .05 level.

TABLE XXVIII

SCHEFFE TEST FOR BETWEEN TEST PWC_{170}/kg.

MEANS FOR OFFENSIVE BACKS

Test I	Test II	Test III	Mean Difference	Critical F	Calculated F
15.49		15.86	.37 NS	6.42	.14
15.49	17.03		1.54 NS	6.42	2.45
	17.03	15.86	1.17 NS	6.42	1.41

NS Not significant at the .05 level.

defensive linemen. No other significant differences were seen within this position.

TABLE XXIX

SCHEFFE TEST FOR BETWEEN TEST PW[illegible]
MEANS FOR DEFENSIVE LINEMEN[illegible]

Test I	Test II	Test III	Mean Difference	Critical F	Calculated F
1369		1486	117 NS	6.42	2.01
1369	1596		227*	6.42	7.58
	1596	1486	110 NS	6.42	1.78

* Significan[illegible] the .05 level.
NS Not signi[illegible] at the .05 level.

Comparisons of mean PWC_{170} and PWC_{170}/kg scores for defensive backs determined no significant differences between any of the tests. A summary of these comparisons appears in Tables XXXI and XXXII (pp. 83, 84).

Figures III and IV (pp. 85, 86) illustrate the mean PWC_{170} and PWC_{170}/kg scores, by position, during the training season. When considering these graphs, it should be noted that defensive backs, by the natu[illegible] of the[illegible] position, have pass coverage responsibilities wh[illegible]robably require more running than the other positions. As well, the defensive backs spent most of their practice time on drills which

TABLE XXX

SCHEFFE TEST FOR BETWEEN TEST PWC_{170}/kg. MEANS FOR DEFENSIVE LINEMEN

Test I	Test II	Test III	Mean Difference	Critical F	Calculated F
14.81		16.24	1.43 NS	6.42	2.40
14.81	17.50		2.69*	6.42	8.51
	17.50	16.24	1.26 NS	6.42	1.86

* Significant at the .05 level.
NS Not significant at the .05 level.

TABLE XXXI

SCHEFFE TEST FOR BETWEEN TEST PWC_{170} MEANS FOR DEFENSIVE BACKS

Test I	Test II	Test III	Mean Difference	Critical F	Calculated F
1273		1402	129 NS	6.42	1.53
1273	1288		15 NS	6.42	.02
	1288	1402	114 NS	6.42	1.19

NS Not significant at the .05 level.

TABLE XXXII

SCHEFFE TEST FOR BETWEEN TEST PWC_{170}/kg. MEANS FOR DEFENSIVE BACKS

Test I	Test II	Test III	Mean Difference	Critical F	Calculated F
17.61		19.63	2.02 NS	6.42	2.99
17.61	17.78		.17 NS	6.42	.02
	17.78	19.63	1.85 NS	6.42	2.51

NS Not significant at the .05 level.

required some form of concentrated running. In contrast, much of the practice time for the offensive linemen, offensive backs, and defensive linemen was spent on play execution and team skills. This required relatively little running in comparison to the defensive backs. Team skills necessary for the defensive backs were taught in conjunction with game-like situations. Therefore, running was a primary concern.

Another point which must be realized is that three linebackers were included in the group of eight defensive linemen. Linebackers are similar to defensive backs in that they also have pass coverage responsibilities. Therefore, the three linebackers in this study spent a substantial amount of their practice time with the defensive backs.

A fifteen minute period at the end of most practices was designated as a conditioning session. It was noted that

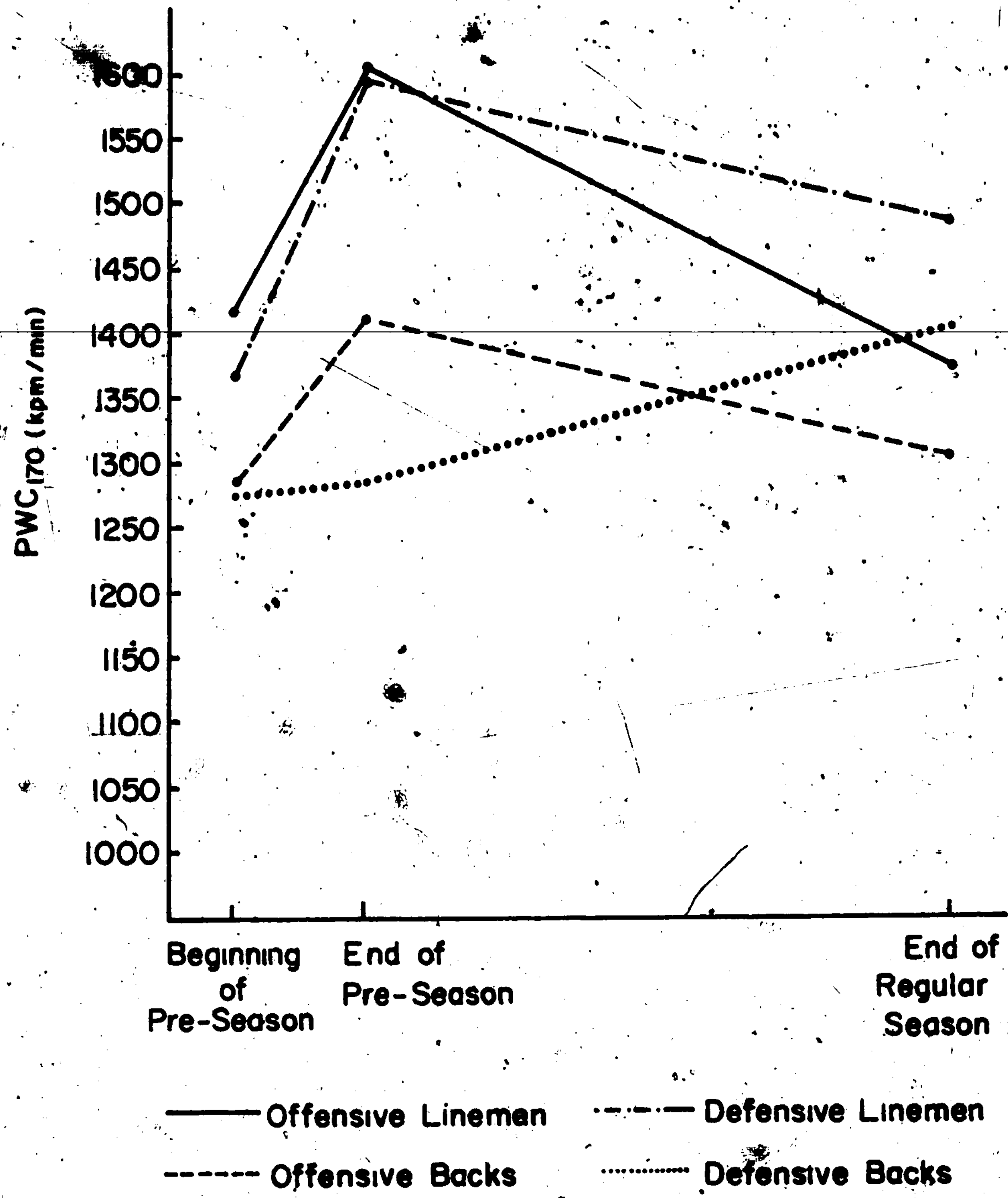

FIGURE III

CHANGES IN MEAN PWC_{170} SCORES DURING THREE TESTING SESSIONS FOR FOOTBALL PLAYERS, BY POSITION

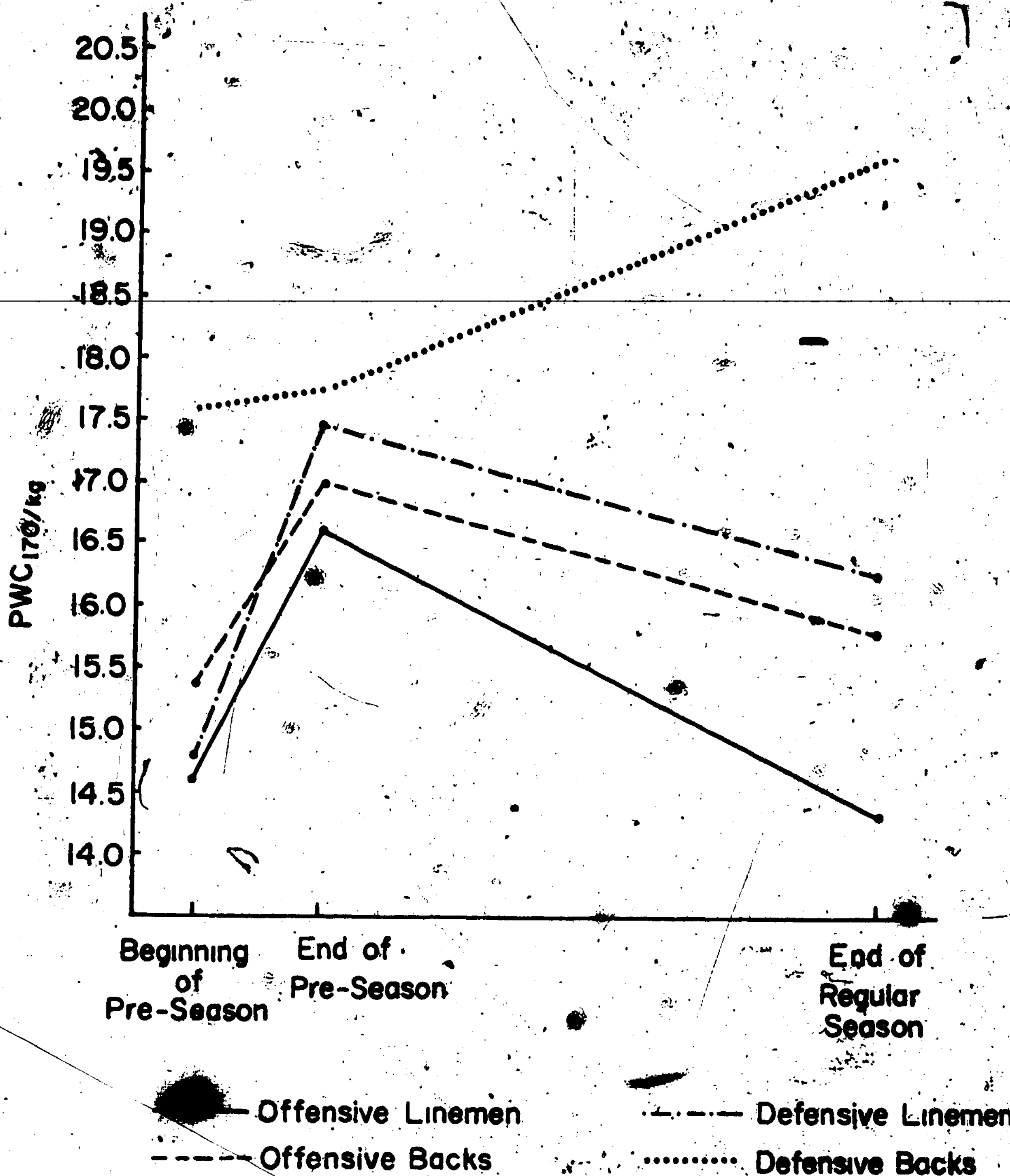

FIGURE IV

CHANGES IN MEAN PWC_{170}/kg. SCORES DURING THREE TESTING SESSIONS FOR FOOTBALL PLAYERS, BY POSITION during some practices, the offensive linemen and offensive backs executed team plays during this time. This required five to ten yard sprints. In obvious contrast, the defensive linemen and defensive backs generally concentrated on more endurance-type conditioning drills.

DIFFERENCES BETWEEN POSITIONS

A two way analysis of variance with repeated measures indicated no significant differences between positions in mean physical work capacity scores. Tables XXI and XXII (pp. 77, 78) summarize this analysis.

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CHAP[illegible]

SUMMARY AND CONCLUSIONS

I. SUMMARY

PURPOSE

The purpose of this study was to compare beginning of pre-season, end of pre-season, and end of regular season physical work capacity scores of intercollegiate football players as measured by a modified Sjostrand PWC_{170} test.

SUBJECTS

The subjects consisted of twenty-six intercollegiate football players from the University of Alberta. The age of the subjects ranged from eighteen to twenty-four years. The mean age was 20.5 years.

EXPERIMENTAL PROCEDURE

The duration of the study was twelve weeks. This included one week prior to the pre-season period, a two week pre-season period, and a nine week regular season period.

Each subject was given a modified Sjostrand PWC_{170} test three times during the twelve week period. The first testing session occurred within the five days immediately prior to the start of the pre-season period. The second testing session was held immediately after the completion [illegible] fourteen day pre-season period. The third and final [illegible] session was held during the last five days of the [illegible] season period.

The subjects participated in two practices a day for the first seven days of the pre-season period. The remaining ten weeks of the season consisted of one practice a day, Monday through Friday, with a game on Saturday. On occasion, Sunday practices were also held.

STATISTICAL ANALYSIS

Two way analyses of variance and Scheffe Tests were used to analyze the data. The .05 level of significance was used in this study.

The physical work capacity scores of the football players were analyzed as a team and by position. In both cases, a two way analysis of variance with repeated measures, was used to test mean differences within and between groups.

When the football data was treated as a group and compared with data obtained from the control group, a Scheffe Test was administered to ascertain within and between which groups significant differences appeared.

When the football data was treated by position, a Scheffe Test was used to determine within which positions and between which positions significant differences occurred.

RESULTS

There was a significant difference between beginning of pre-season and end of pre-season mean PWC_{170} scores for the football players, as a group. A significant increase in mean PWC_{170}/kg. scores for the football players was also seen between beginning of pre-season and end of pre-season tests. No significant differences appeared between beginning of pre-season and end of regular season mean PWC_{170} or PWC_{170}/kg. scores for the football players, as a group. Differences between end of pre-season and end of regular season mean PWC_{170} and PWC_{170}/kg. scores for the football players, as a group, were also found to be insignificant.

There were significant differences between football and control group mean PWC_{170} scores at each of the three tests. No significant differences occurred between football and control group mean PWC_{170}/kg. scores at any of the testing sessions.

Comparisons of the football players, within each position, revealed significant increases between beginning of pre-season and end of pre-season mean PWC_{170} and PWC_{170}/kg. scores for defensive linemen. No significant differences in physical work capacity were seen within either of the other three positions.

Comparisons of mean physical work capacities, between positions at each testing session, revealed no significant differences.

II. CONCLUSIONS

Within the limits of this study the following conclusions have been made:

(1) There was a significant increase between beginning of pre-season and end of pre-season mean PWC_{170} and PWC_{170}/kg. scores for the football players, as a group.

(2) There was a significant increase between beginning of pre-season and end of pre-season mean PWC_{170} and PWC_{170}/kg. scores for the defensive linemen. However, no significant differences were apparent between beginning of pre-season and end of pre-season mean PWC_{170} or PWC_{170}/kg. scores for offensive linemen, offensive backs or defensive backs.

(3) There was no significant difference between beginning of pre-season and end of regular season mean PWC_{170} or PWC_{170}/kg. scores for the football players, as a group.

(4) There were no significant differences between beginning of pre-season and end of regular season mean PWC_{170} or PWC_{170}/kg. scores for any of the four positions.

(5) There was no significant difference between end of pre-season and end of regular season mean PWC_{170} or PWC_{170}/kg. scores for the football players, as a group.

(6) There were no significant differences between end of pre-season and end of regular season mean PWC_{170} or PWC_{170}/kg. scores for any of the four positions.

(7) There were no significant differences in mean PWC_{170} or PWC_{170}/kg. scores between any of the four positions at the beginning of the pre-season.

(8) There were no signtficant differences in mean PWC_{170} or PWC_{170}/kg. scores between any of the four positions at the end of the pre-season.

(9) There were no significant differences in mean PWC_{170} or PWC_{170}/kg. scores between any of the four positions at the end of the regular season.

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APPENDIX A

TREATMENT OF THE DATA

The raw data obtained during the testing sessions was converted into PWC_{170} and PWC_{170}/kg. values by the use of an APL program. The computer used was an IBM 360/67.

The APL program used was as follows:

```
     ∇ BON
[1]    N←ρX
[2]    SX←+/X
[3]    SY←+/Y←(B÷4)×6×W
[4]    COV←+/X×Y
[5]    SSX←+/X*2
[6]    BYX←(COV-((SX×SY)÷N))÷(SSX-((SX*2)÷N))
[7]    AYX←(SY-(BYX×SX))÷N
[8]    WO130←(BYX×130)+AYX
[9]    WO150←(BYX×150)+AYX
[10]   WO170←(BYX×170)+AYX
[11]   AGEFAC←(A×¯0.00908)+1.212
[12]   →(Z=1)/17
[13]   PREVO2L←(0.00277×WO170)+0.12
[14]   PREV←(PREVO2L÷(G÷2.2))×1000
[15]   PREVOCOR←PREV×AGEFAC
[16]   →20
[17]   PREVO2L←(0.002467×WO170)+0.51
[18]   PREV←(PREVO2L÷(G÷2.2))×1000
[19]   PREVOCOR←PREV×AGEFAC
[20]   →21
[21]   WOKG130←WO130÷(G÷2.2)
[22]   WOKG150←WO150÷(G÷2.2)
[23]   WOKG170←WO170÷(G÷2.2)
[24]   S
[25]   WO130,WO150,WO170
[26]   WOKG130,WOKG150,WO170
[27]   PREVO2L
[28]   PREVOCOR
```

APPENDIX B

ANTHROPOMETRIC DATA OF THE SUBJECTS

PHYSICAL CHARACTERISTICS OF THE FOOTBALL PLAYERS

		Age in Years	Height in Inches	Weight: Beginning of Pre-Season		End of Pre-Season		End of Regular Season	
Subject				Pounds	Kilograms	Pounds	Kilograms	Pounds	Kilograms
1	JB	20.08	73	221	100.45	220	100.00	216	98.18
2	RB	20.00	72	176	80.00	176	80.00	177	80.45
3	BC	21.66	68	185	84.09	183	83.18	184	83.64
4	VC	21.33	74	195	88.64	195	88.64	193	87.73
5	BF	20.08	72	177	80.45	174	79.09	175	79.55
6	GG	18.16	69	156	70.91	158	71.82	158	71.82
7	JH	18.00	70	165	75.00	165	75.00	166	75.45
8	GI	19.00	73	180	81.82	184	83.64	184	83.64
9	BJ	23.33	74	228	103.64	227	103.18	228	103.64
10	GK	20.00	73	190	86.36	190	86.36	190	86.36
11	WK	22.41	68	205	93.18	205	93.18	200	90.91
12	KL	20.33	75	226	102.73	226	102.73	228	103.64
13	LL	18.16	75	202	91.82	200	90.91	201	91.36
14	LM	24.00	68	152	69.09	151	68.64	149	67.73
15	EM	19.75	73	245	111.36	243	110.45	245	111.36
16	PP	19.08	72	218	99.09	210	95.45	212	96.36
17	TP	24.16	70	177	80.45	176	80.00	172	78.18
18	JR	20.16	74	220	100.00	217	98.64	218	99.09
19	DS	20.00	70	175	79.55	173	78.64	170	77.27
20	AS	20.66	72	242	110.00	237	107.73	234	106.36
21	DS	23.00	70	183	83.18	184	83.64	183	83.18
22	JS	22.08	73	195	88.64	193	87.73	193	87.73
23	TT	20.41	72	210	95.45	209	95.00	210	95.45
24	LW	21.83	67	159	72.27	157	71.36	158	71.82
25	GW	21.75	71	170	77.27	170	77.27	170	77.27
26	GW	21.83	68	155	70.45	158	71.82	153	69.55

PHYSICAL CHARACTERISTICS OF THE CONTROL GROUP

Subject		Age in Years	Height in Inches	Weight: Beginning of Pre Season Pounds	Beginning of Pre Season Kilograms	End of Pre-Season Pounds	End of Pre-Season Kilograms	End of Regular Season Pounds	End of Regular Season Kilograms
1	WB	18.33	67	140	63.64	142	64.55	143	65.00
2	MB	18.00	79	172	78.18	175	79.55	182	82.73
3	JC	18.75	78	130	59.09	130	59.09	127	57.73
4	JD	19.66	65	132	60.00	130	59.09	127	57.73
5	RE	19.16	71	172	78.18	175	79.55	172	78.18
6	TF	18.41	70	122	55.45	120	54.55	122	55.45
7	BG	17.75	74	160	72.73	168	76.36	171	77.73
8	DA	18.25	68	152	69.09	149	67.73	151	68.64
9	RH	21.33	68	155	70.45	156	70.91	155	70.45
10	RH	19.16	63	123	55.91	120	54.55	122	55.45
11	RJ	17.50	70	145	65.91	144	65.45	147	66.82
12	DL	18.41	65	131	59.55	133	60.45	135	61.36
13	KM	22.00	68	141	64.09	140	63.64	142	64.55
14	AM	33.00	74	205	93.18	204	92.73	205	93.18
15	DP	18.66	70	158	71.82	162	73.64	[illegible]	71.36
16	PR	18.25	69	143	65.00	144	65.45	143	65.00
17	JS	18.58	69	144	65.45	144	65.45	146	66.36
18	DT	17.83	69	141	64.09	140	63.64	[illegible]	63.18
19	AV	19.33	67	119	54.09	117	53.18	118	53.64

PHYSICAL CHARACTERISTICS OF THE FOOTBALL PLAYERS BY POSITION

OFFENSIVE LINEMEN

Subject		Age in Years	Height in Inches	Weight: Beginning of Pre-Season		Weight: End of Pre-Season		Weight: End of Regular Season	
				Pounds	Kilograms	Pounds	Kilograms	Pounds	Kilograms
1	JB	20.08	73	221	100.45	220	100.00	216	98.18
4	VC	21.33	74	195	88.64	195	88.64	193	87.73
11	WK	22.41	68	205	93.18	205	93.18	200	90.91
15	EM	19.75	73	245	111.36	243	100.45	245	111.36
16	PP	19.08	72	218	99.09	210	95.45	212	96.36
18	JR	20.16	74	220	100.00	217	98.64	218	99.09

PHYSICAL CHARACTERISTICS OF THE FOOTBALL PLAYERS BY POSITION

OFFENSIVE BACKS

Subject		Age in Years	Height in Inches	Weight: Beginning of Pre-Season Pounds	Weight: Beginning of Pre-Season Kilograms	Weight: End of Pre-Season Pounds	Weight: End of Pre-Season Kilograms	Weight: End of Regular Season Pounds	Weight: End of Regular Season Kilograms
2	RB	20.00	72	176	80.00	176	80.00	177	80.45
5	BF	20.08	72	177	80.45	174	79.09	175	79.55
7	JH	18.00	70	165	75.00	165	75.00	166	75.45
10	GK	20.00	73	190	86.36	190	86.36	190	86.36
21	DS	23.00	70	183	83.18	184	83.64	183	83.18
23	TT	20.41	72	210	95.45	209	95.00	210	95.45
25	GW	21.75	71	170	77.27	170	77.27	170	77.27

PHYSICAL CHARACTERISTICS OF THE FOOTBALL PLAYERS BY POSITION

DEFENSIVE LINEMEN

Subject		Age in Years	Height in Inches	Weight: Beginning of Pre-Season		Weight: End of Pre-Season		Weight: End of Regular Season	
				Pounds	Kilograms	Pounds	Kilograms	Pounds	Kilograms
3	BC	21.66	68	185	84.09	183	83.18	184	83.64
8	GI	19.00	73	180	81.82	184	83.64	184	83.64
9	BJ	23.33	74	228	103.64	227	103.18	228	103.64
12	KL	20.33	75	226	102.73	226	102.73	228	103.64
13	LL	18.16	75	202	91.82	200	90.91	201	91.36
17	TP	24.16	70	177	80.45	176	80.00	172	78.18
20	AS	20.66	72	242	110.00	237	107.37	234	106.36
22	JS	22.08	73	195	88.64	193	87.73	193	87.73

PHYSICAL CHARACTERISTICS OF THE FOOTBALL PLAYERS BY POSITION

DEFENSIVE BACKS

Subject		Age in Years	Height in Inches	Weight: Beginning of Pre-Season		End of Pre-Season		End of Regular Season	
				Pounds	Kilograms	Pounds	Kilograms	Pounds	Kilograms
6	GG	18.16	69	156	70.91	158	71.82	158	71.82
14	LM	24.00	68	152	69.09	151	68.64	149	67.73
19	DS	20.00	70	175	79.55	173	78.64	170	77.27
24	LW	21.83	67	159	72.27	157	71.36	158	71.82
26	GW	21.83	68	155	70.45	158	71.82	153	69.55

APPENDIX C

PHYSICAL WORK CAPACITY SCORES OF THE SUBJECTS

PWC_{170} AND PWC_{170} PER KILOGRAM OF BODY WEIGHT SCORES FOR THE FOOTBALL PLAYERS

Subject		Beginning of Pre-Season		End of Pre-Season		End of Regular Season	
		PWC_{170}	PWC_{170}/kg.	PWC_{170}	PWC_{170}/kg.	PWC_{170}	PWC_{170}/kg.
1	JB	1048.33	10.43	1613.79	16.13	1280.23	13.03
2	RB	1392.83	17.41	1500.56	18.75	1405.51	17.46
3	BC	1346.83	16.00	1607.34	19.32	1517.88	18.14
4	VC	1898.40	21.41	2164.75	24.42	1978.02	22.54
5	BF	1406.44	17.48	1566.32	19.80	1363.36	17.13
6	GG	1343.67	18.94	1563.16	21.76	1495.04	20.81
7	JH	718.89	9.58	668.83	8.91	1216.83	16.12
8	GI	1413.89	17.28	1677.50	20.05	1466.15	17.53
9	BJ	1599.32	15.43	1449.17	14.04	1808.37	17.44
10	GK	1326.84	15.36	1486.57	17.21	1263.71	14.63
11	WK	1392.40	14.94	1111.73	11.93	1265.68	13.92
12	KL	1396.03	13.58	1955.18	19.03	1287.48	12.42
13	LL	1415.43	15.41	1956.63	21.52	1672.63	18.30
14	LM	1497.01	21.66	1283.72	18.70	1677.31	24.76
15	EM	1120.80	10.06	1370.13	12.40	1119.78	10.05
16	PP	1821.30	18.38	1795.13	18.80	1477.43	15.33
17	TP	1105.64	13.74	1459.27	18.24	1283.77	16.42
18	JR	1243.30	12.43	1568.84	15.90	1112.11	11.22
19	DS	1309.78	16.46	1387.18	17.64	1434.69	18.56
20	AS	1443.80	13.12	1228.98	11.40	1406.77	13.22
21	DS	1119.55	13.45	1253.57	14.98	1113.77	13.38
22	JS	1233.88	13.92	1435.71	16.36	1442.97	16.44
23	TT	1747.48	18.30	1943.37	20.45	1523.57	15.96
24	LW	1341.67	18.56	1064.33	14.91	1227.65	17.09
25	GW	1299.78	16.82	1476.37	19.10	1258.46	16.28
26	GW	873.08	12.39	1141.56	15.89	1177.74	16.93

PWC_{170} AND PWC_{170} PER KILOGRAM OF BODY WEIGHT SCORES FOR THE CONTROL GROUP

Subject		Beginning of Pre-Season		End of Pre-Season		End of Regular Season	
		PWC_{170}	PWC_{170}/kg.	PWC_{170}	PWC_{170}/kg.	PWC_{170}	PWC_{170}/kg.
1	WB	964.96	15.16	737.45	11.42	1001.95	15.41
2	MB	687.77	8.79	798.97	10.04	830.02	10.03
3	JC	751.04	12.70	1031.78	17.15	1087.19	18.83
4	JD	819.83	13.66	934.00	15.80	1030.11	17.84
5	RE	1361.06	17.40	1165.41	14.65	1318.87	16.86
6	TF	1209.37	21.80	1255.25	23.01	1213.45	21.88
7	BG	1020.37	14.03	1037.19	13.58	1094.62	14.08
8	DG	1188.31	17.19	1396.25	20.61	1248.16	18.18
9	RH	1096.27	15.56	1252.43	17.66	1164.00	16.52
10	RH	1043.36	18.66	988.20	18.11	1201.01	21.65
11	RJ	1050.37	15.93	1107.53	16.92	1216.60	18.20
12	DL	761.24	12.78	939.44	15.53	1104.17	17.99
13	KM	1131.82	17.65	1065.29	16.74	1112.57	17.23
14	GM	1477.87	15.86	1000.70	10.79	1379.31	14.80
15	DP	936.13	13.03	1194.32	16.21	3188.73	19.46
16	PR	837.71	12.88	874.94	13.36	1282.28	19.72
17	JS	947.03	14.46	1159.67	17.71	1039.29	15.66
18	DT	1107.05	17.27	1383.89	21.74	1268.36	20.07
19	AV	806.40	14.90	889.28	16.72	893.51	16.65

PWC_{170} AND PWC_{170} PER KILOGRAM OF BODY WEIGHT SCORES FOR THE OFFENSIVE LINEMEN

Subject		Beginning of Pre-Season		End of Pre-Season		End of Regular Season	
		PWC_{170}	PWC_{170}/kg.	PWC_{170}	PWC_{170}/kg.	PWC_{170}	PWC_{170}/kg.
1	JB	1048.33	10.43	1613.79	16.13	1280.23	13.03
4	VC	1898.40	21.41	2164.75	24.42	1978.02	22.54
11	WK	1392.40	14.94	1111.73	11.93	1265.68	13.92
15	EM	1120.80	10.06	1370.13	12.40	1119.78	10.05
16	PP	1821.30	18.38	1795.13	18.80	1477.43	15.33
18	JR	1243.30	12.43	1568.84	15.90	1112.11	11.22

PWC_{170} AND PWC_{170} PER KILOGRAM OF BODY WEIGHT SCORES
FOR THE OFFENSIVE BACKS

Subject		Beginning of Pre-Season		End of Pre-Season		End of Regular Season	
		PWC_{170}	PWC_{170}/kg.	PWC_{170}	PWC_{170}/kg.	PWC_{170}	PWC_{170}/kg.
2	RB	1392.83	17.41	1500.56	18.75	1405.51	17.46
5	BF	1406.44	17.48	1566.32	19.80	1363.36	17.13
7	JH	718.89	9.58	668.83	8.91	1216.83	16.12
10	GK	1326.84	15.36	1486.57	17.21	1263.71	14.63
21	DS	1119.55	13.45	1253.57	14.98	1113.77	13.38
23	TT	1747.48	18.30	1943.37	20.45	1523.57	15.96
25	GW	1299.78	16.82	1476.37	19.10	1258.46	16.28

PWC_{170} AND PWC_{170} PER KILOGRAM OF BODY WEIGHT SCORES
FOR THE DEFENSIVE LINEMEN

Subject		Beginning of Pre-Season		End of Pre-Season		End of Regular Season	
		PWC_{170}	PWC_{170}/kg.	PWC_{170}	PWC_{170}/kg.	PWC_{170}	PWC_{170}/kg.
3	BC	1346.08	16.00	1607.34	19.32	1517.88	18.14
8	GI	1413.89	17.28	1677.50	20.05	1466.15	17.53
9	BJ	1599.32	15.43	1449.17	14.04	1808.37	17.44
12	KL	1396.03	13.58	1955.18	19.03	1287.48	12.42
13	LL	1415.43	15.41	1956.63	21.52	1672.63	18.30
17	TP	1105.64	13.74	1459.27	18.24	1283.77	16.42
20	AS	1443.80	13.12	1228.98	11.40	1406.47	13.22
22	JS	1233.88	13.92	1435.71	16.36	1442.97	16.44

PWC_{170} AND PWC_{170} PER KILOGRAM OF BODY WEIGHT SCORES
FOR THE DEFENSIVE BACKS

Subject		Beginning of Pre-Season		End of Pre-Season		End of Regular Season	
		PWC_{170}	PWC_{170}/kg.	PWC_{170}	PWC_{170}/kg.	PWC_{170}	PWC_{170}/kg.
6	GG	1343.67	18.94	1563.16	21.76	1495.04	20.81
14	LM	1497.01	21.66	1283.72	18.70	1677.31	24.76
19	DS	1309.78	16.46	1387.18	17.64	1434.69	18.56
24	LW	1341.67	18.56	1064.33	14.91	1227.65	17.09
26	GW	873.08	12.39	1141.56	15.89	1177.74	16.93

APPENDIX D

INDIVIDUAL RECORD SHEET

UNIVERSITY OF ALBERTA PHYSICAL WORK CAPACITY STUDY

ON INTERCOLLEGIATE FOOTBALL PLAYERS

DEPARTMENT OF PHYSICAL EDUCATION

DATA CARD

NAME ____________ DATE OF BIRTH ____________

HEIGHT (inches) ____________ WEIGHT (pounds) ____________

(kgs) ____________

POSITION PLAYED ____________ DATE OF TESTING ____________

(a) Resting Heart Rate - ________ (beats/min.)

(b) Exercise Heart Rate - 4 minutes ________ (beats/min.)

- 8 minutes ________ (beats/min.)

-12 minutes ________ (beats/min.)

(c) Pedal Revolutions - 4 minutes ________ Total ________ Average

- 8 minutes ________ Total ________ Average

-12 minutes ________ Total ________ Average

(d) Tension - 4 minutes ____ kp Workload ____ kpm/min.

- 8 minutes ____ kp Workload ____ kpm/min.

-12 minutes ____ kp Workload ____ kpm/min.

(e) PWC_{170} ____________

(f) $PWC_{170/kg}$ ____________

(g) REMARKS ____________

APPENDIX E

TAPE RECORDED INSTRUCTIONS GIVEN TO EACH SUBJECT BEFORE PERFORMING TEST I

The test you are about to take is called a physical work capacity test. This test consists of riding the bicycle for twelve consecutive minutes. The work load will be increased at the end of the fourth and eighth minutes of exercise. While pedalling, you should try to keep in time with the "beeps" of the metronome. This will enable you to pedal at a rate of sixty revolutions per minute. This test is not a maximal test and you will not be expected to ride to exhaustion. This test is a submaximal test and is designed to raise your heart rate to approximately 170 beats per minute. If you have any questions, please ask them now.

APPENDIX F

HEART RATE CONVERSION SHEET

HEART RATE FROM ECG - RATE = 25/mm/sec.

Distance of 3 Beats	Heart Rate	Distance of 3 Beats	Heart Rate	Distance of 3 Beats	Heart Rate
17	265	36.5	123	56	80
17.5	257	37	122	56.5	80
18	250	37.5	120	57	79
18.5	243	38	118	57.5	78
19	237	38.5	117	58	78
19.5	231	39	115	58.5	77
20	225	39.5	114	59	76
20.5	220	40	113	59.5	76
21	214	40.5	111	60	75
21.5	209	41	110	60.5	74
22	204	41.5	108	61	74
22.5	200	42	107	61.5	73
23	195	42.5	106	62	73
23.5	191	43	105	62.5	72
24	187	43.5	103	63	71
24.5	184	44	102	63.5	71
25	180	44.5	101	64	70
25.5	176	45	100	64.5	70
26	173	45.5	99	65	69
26.5	170	46	98	65.5	69
27	167	46.5	97	66	68
27.5	164	47	96	66.5	68
28	161	47.5	95	67	67
28.5	158	48	94	67.5	67
29	155	48.5	93	68	66
29.5	153	49	92	68.5	66
30	150	49.5	91	69	65
30.5	148	50	90	69.5	65
31	145	50.5	89	70	64
31.5	143	51	88	71	63
32	141	51.5	87	72	62
32.5	138	52	87	73	61
33	136	52.5	86	74	61
33.5	134	53	85	75	60
34	132	53.5	84	76	60
34.5	130	54	83	77	59
35	129	54.5	83	78	58
35.5	127	55	82	79	57
36	125	55.5	81	80	55

APPENDIX G

THE FOOTBALL TEAM'S WEEKLY PRACTICE SCHEDULE

THE GOLDEN BEAR PRACTICE WEEK.

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
12:00 Warm-up 10	5:15 Pre-Practice 15	5:15 Pre-Practice 15	5:15 Pre-Practice 15	5:15 Pre-Practice 15	5:15 Pre-Practice 15
12:10 Team Run 20	5:30 Team Cals & the Kicking Game 15	5:30 Team Cals & the Kicking Game 15	5:30 Team Cals & the Kicking Game 15	5:30 Team Cals & the Kicking Game 15	5:30 Team Cals & the Kicking Game 20
	5:45 Primary Group Agility 15	5:45 Primary Group Agility 15	5:45 Primary Group Agility 15 (*Secondary)	5:45 Primary Group Agility 15	5:50 Primary Group Agility 10
	6:00 Defensive & Offensive Additions 20	6:00 Team Defence 15	6:00 Live System Drills 15	6:00 Team Defence vs Opponent 30	6:00 Team Defence 10
	6:20 Wt. Program (Offence) & Team Conditioning 15	6:15 Team Offence 30	6:15 Team Offence 15	6:30 Team Offence vs Opponent 30	6:10 Team Offence 20
	6:35 Films 45	6:45 Wt. Program (Defence) & Team Conditioning	6:30 Team Defence 25	7:00 Wt. Program (Defence) & Team Conditioning 15	
			6:55 Wt. Program (Offence) Team Conditioning 15		
12:30 30 Min.	7:20 2 Hrs. 5 Min.	7:00 1 Hr. 45 Min.	7:10 1 Hr. 55 Min.	7:15 2 Hrs. 0 Min.	6:30 1 Hr. 15 Min.