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Physical fitness changes in male and female college basketball players

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PHYSICAL FITNESS CHANGES IN MALE AND FEMALE COLLEGE BASKETBALL PLAYERS

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THESIS ACCEPTANCE

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DEDICATION

To Emogene Nelson - her wisdom, guidance, friendship and courage were an inspiration to many of us. Her spirit will live in all she helped and cared for.

To my family, especially my parents. Without their support and motivation to be the best I could be I would not be what I am today. Their love for all of us has always been visible and with us wherever we go.

TABLE OF CONTENTS

LIST OF TABLES

Abstract

Nine female and four male basketball players at the University of Nebraska at Omaha completed pre- and post-season testing to measure and compare the physiological changes which occurred over the course of a competitive season of intercollegiate basketball. Cardiorespiratory fitness ($\dot{V}O_2$ max), muscular strength, muscular endurance and body composition were the variables measured. The results showed a significant (p=.05) increase in $\dot{V}O_2$ max ($l \cdot min^{-1}$) for both the males and females. The women showed a significant (p=.05) increase in $\dot{V}O_2$ max ($ml \cdot kg^{-1} . min^{-1}$). No other significant changes occurred within either group. Between group comparisons found a significant (p=.01) decrease in lower extremity strength in the females.

The results of this study show that for this group of U.N.O. Basketball players, similar physical fitness changes occurred in each group with the females having a significant decrease in lower extremity strength over the course of a competitive season of college basketball.

CHAPTER I

INTRODUCTION

Research of the past 20 years has produced numerous descriptive profiles of a variety of male athletic populations. Athletic populations studied have included major league baseball (Coleman, 1981), men's volleyball (Conlee, McGown, Fisher, Dalsky & Robinson, 1982; Gladden & Colacino, 1978), and football (Wilmore, 1972). The increased female participation in sports of the past ten years has stimulated research on female athletes. Female athletic populations studied include volleyball (Hassler, Morrow & Jackson, 1978; Kovaleski, Parr, Nornak & Roitman, 1980; Spence, Disch, Fred & Coleman, 1980), basketball (McArdle, Magel & Kyvallos, 1971; Sinning & Adrian, 1968; Sinning, 1973), distance runners, (Vaccaro, Morris & Clarke, 1975), and pentathletes (Kraehnbuhl, Wells, Brown & Ward, 1979). The majority of theses studies provide descriptive data on the physiological parameters of maximal oxygen consumption ($\dot{V}O_2$ max), muscular strength, muscular endurance and body composition. These data are useful in that they provide physiological profiles of athletes which may serve as guidelines for recruiting athletes with similar capacities or training levels. However, these profiles represent measurements taken at random times during the competitive season, they do not provide data on the changes that occur during the season (Grenn & Huston, 1975; Hanson, 1975; Kelly, Gorney & Kalm, 1978; McArdle, Magel & Kyvallos, 1971; Shaver, 1974; Sinning, 1973; Sinning & Adrian, 1968).

Considerable research has dealt with the physiological response of male athletes to training (Ekblom & Hermanson, 1968; Ekblom, Astrand, Saltin, Stenberg & Wallstrom, 1968 Faria, 1970; Fox, Bartels, Billings, O'Brien, Bason & Mathews, 1975; Karlsson, Nordesjo, Jorfeldt & Saltin, 1972; Pollock, Cureton & Greninger, 1969; Saltin & Astrand, 1967). A lesser amount of data are available with female athletes (Eisenman & Goldberg, 1975; Michael, Evert & Jeffers, 1972; Wallace, 1975). These studies demonstrated that the female response to training is similar to that of men. Decreases in resting heart rate, total body weight and percent body fat were found as well as increases in $\dot{V}O_2$ max.

Several studies have investigated the physiological changes occuring over the course of a season of competition. Sports studied include ice hockey (Green & Huston, 1975). college wrestlers (Kelly, Gorney & Kalm, 1978), Nordic ski racers (Hanson, 1975), and female college basketball players (McArdle, Magel & Kyvallos, 1971; Sinning, 1973; Sinning & Adrian, 1968). Hanson (1975) found no significant changes in percent body fat, $\dot{V}O_2$ max, or respiratory exchange ratio (R) in Nordic ski racers. Hanson concluded that this was possibly due to the strenuousness of in-season travel, initial level of conditioning, the increasingly large amount of time spent in mental and technical preparation and reduced time for practice in the latter part of the season.

It was the purpose of this study to examine and compare changes in cardiorespiratory fitness, muscular strength, muscular endurance and body composition of male and female college basketball players over the course of a competitive season. Current season lengths, competitive schedules and training programs are becoming increasingly similar among many men's and women's athletic teams. Little if any research has recently been completed comparing male and female athletes in similar athletic activities. This study was designed to make such comparisons.

CHAPTER II

THE PROBLEM

Statement of the Problem

The purpose of this study was to examine and compare cardiorespiratory fitness, muscular strength, muscular endurance and body composition of male and female college basketball players over the course of a competitive season.

Hypotheses

It was hypothesized that significant changes could occur in both male and female athletes in the following variables:

1. increase in maximal oxygen consumption ($\dot{V}O_2$ max $l \cdot min^{-1}$, $ml \cdot kg^{-1} \cdot min^{-1}$)
2. increase in muscular strength
3. increase in muscular endurance
4. increase in lean body weight
5. decrease in fat weight
6. decrease in percent body fat

Delimitations

Subjects were four male and nine female collegiate basketball players at the University of Nebraska at Omaha. The mean age for each group was 20.5 and 20.3 for the men and women respectively. The practice sessions lasted two and one-half hours. Each group competed an average of two days per week over a 22 and 24 week period for the women and men respectively. The length of this study coincided with the pre-competitive and competitive seasons of each team.

Limitations

Injuries, playing time, practice effort, selection of subjects and the number of players competing and practicing with each team could not be controlled and may have affected the results of this study. The small number of athletes participating in this study may have affected the power of the statistical tests and limited the generalizations about the results.

CHAPTER III

REVIEW OF RELATED LITERATURE

The review has been divided into sections dealing with 1) the energy systems predominant in basketball, 2) the physiological response to training, and 3) past research dealing with the physiological changes that occur over the course of a season. Studies pertaining to these topics will be discussed in this chapter.

Energy Systems Predominant in Basketball

The human body produces energy through aerobic and anaerobic metabolic pathways. Exercise physiologists have classified these pathways into three systems which facilitate understanding the dynamics of muscle substrate utilization. Fox & Mathews (1981) classify these as 1) the aerobic system, 2) the lactic acid system and 3) the phosphagen system (ATP-CP). All three energy systems resynthesize ATP, the chemical which provides energy for muscle contraction. Each mole of ATP yields seven to 12 kilocalories of energy when the phosphate bond is broken and ADP is formed (Fox & Mathews, 1981). Each of these systems produces a varying quantity of ATP from each mole of substrate used.

Aerobic metabolism relies primarily upon the oxidation of carbohydrate and fat with protein playing a minor role. It is the most productive of the three energy systems in terms of the quantity of ATP produced. From one molecule of glycogen, aerobic metabolism can produce 39 moles of ATP. This is accomplished through the reactions of Kreb's Citric Acid Cycle and the respiratory chain transport system. This is the primary energy system used in work sustained for more than several minutes.

A variety of researchers have provided data on the $\dot{V}O_2$ max capabilities of both trained and untrained subjects. Drinkwater (1973) has reported $\dot{V}O_2$ max ranges for females from 30-40 $ml \cdot kg^{-1} \cdot min^{-1}$ in untrained subjects. Saltin & Astrand (1967) have reported values for female 800-1500 meter runners at 52 $ml \cdot kg^{-1} \cdot min^{-1}$ and a value of 20 $ml \cdot kg^{-1} \cdot min^{-1}$ for housewives. $\dot{V}O_2$ max values for men vary in much the same way. Drinkwater (1973) reported ranges for untrained men at 45-53 $ml \cdot kg^{-1} \cdot min^{-1}$ while Saltin & Astrand (1967) reported male 3000 meter runners with values averaging 58 $ml \cdot kg^{-1} \cdot min^{-1}$ in bicycle ergometer tests. Costill, Daniels, Evans, Fink, Kraehnbuhl and Saltin (1976) have reported values averaging 70 $ml \cdot kg^{-1} \cdot min^{-1}$ in Nordic ski racers.

Activities of short duration such as the 100 and 400 meter dashes, volleyball, badminton and basketball require anaerobic metabolism as their major source of energy (Fox & Mathews, 1981; deVries, 1980). Muscle phosphagen is the most rapidly available source of ATP for use by the muscles. When phosphate is removed from the ATP molecule, a large amount of energy is liberated and immediately available for use. This makes it the energy system which is used for short duration, explosive work. The half-life of ATP-CP is 20 seconds which allows it to be replenished rapidly during the activities mentioned above (deVries, 1980).

Lactic acid metabolism results from anaerobic glycolysis and the terms are often used interchangeably. It is a second system in which ATP is resynthesized. within the muscle. In this system carbohydrate is broken down through 12 separate chemical reactions. These reactions produce one to three moles of ATP per molecule of glucose split. When lactic acid accumulates to high levels in the muscles it inhibits a number of chemical reactions and interferes with the contractile mechanism of muscle. Untrained subjects are able to tolerate 60 to 70 mg% in short term maximal work while elite athletes can tolerate 120 to 140 mg% (Ekblom, Astrand, Saltin, Stenberg & Wallstrom, 1968; Fox & Mathews, Grimby, Huggendal & Saltin, 1967). Although the ATP yield per unit of time from anaerobic glycolysis is less than that of phosphagen, energy is still produced at a rapid rate (1.6 moles of ATP per minute for phosphagen as compared to 3.6 moles for ATP-CP) (Fox & Mathews, 1981).

Basketball is an explosive yet relatively prolonged sport. There are enough breaks in play and changes in activity to allow ATP-CP resynthesis and to keep lactic acid levels relatively low during much of the game. de Vries (1980), Fox & Mathews (1981) and Wilmore (1982) all classify basketball as a sport 85 percent dependant upon the ATP-CP system and 15 percent dependant upon the lactic acid system for energy. These data suggest the importance of measuring the changes in the anaerobic energy system as well as the aerobic system as the conditioning responses may be quite specific.

Response to Training

Cardiorespiratory Endurance

The most frequently used measure of cardiorespiratory fitness is presently $\dot{V}O_2$ max. Untrained young adults have been reported as having VO_2 max scores ranging from 30-40 $ml \cdot kg^{-1} \cdot min^{-1}$ in females and 45-53 $ml \cdot kg^{-1} \cdot min^{-1}$ in males Drinkwater (1973). In a study using teenage girls, Michael, Evert & Jeffers (1972) found significan increases in $\dot{V}O_2$ max, after 12 weeks of interval training. Eisenman & Golding (1975) found significant increases in $\dot{V}O_2$ max and a significant decrease in HR max. The subjects in this study were girls and young women who trained 14 weeks, three days per week for 30 minutes. They also found that age did not significantly affect the increases. Ekblom et al (1968) found a 16.2 percent increase in $\dot{V}O_2$ max and a 52 percent increase in total work output in men over a four month training period consisting of cross country running.

Muscular Fitness

A discussion of muscular fitness and the changes which occur as a result of training need to cover both the general changes as they relate to strength, endurance and hypertrophy as well as the biochemical changes within the muscle cell. Retention of strength and endurance as well as the mode of exercise needs to also be considered in discussing the response to training.

Wilmore (1974) found significant strength gains in both men and women consequent to a 10 week weight training program. Similar results were obtained by Brown & Wilmore (1974) using a group of women as subjects on a program of three days per week and 80-90 percent of a one repetition maximum lift (1RM). Mayhew & Gross (1975) found similar significant increases in strength and decreases in fat weight in women on a high intensity, high resistance training program. Gordon (1967) and Goldberg (1975) found varying degrees of muscular hypertrophy with a variety of different exercise modes (i.e. 3 sets of 10 repetitions versus 3 sets of 5 repetitions). Gordon stated that the increase was due to an increase in sarcoplasmic proteins. Goldber (1975) defined the reason for individual muscle hypertrophy as follows. 1) increased number and size of the myofibrils per muscle fiber, 2) increased total amount of contractile proteins in the myosin filaments, and 3) increased capillary density. Gonyea (1980) studied cats and found a 20.5 percent increase in muscle fiber number in the group lifting a heavy weight (1 kg) due to longitudinal fiber splitting. The grouplifting the lighter weights (1 kg) showed no significant increase. Dons, Bollerup, Bonde-Peterson & Hancke (1979) found that a high percentage of fast twitch fibers is a prerequisite for achievement of large gains in strength. Fast twitch muscle fiber stimulation increases progressively with greater levels of tension. Elite sprinters characteristically show fast twitch fibers distributions of 75-80 percent as compared to endurance athletes with 25-30 percent distribution of fast twitch fibers (Costill et al, 1976; de Vries, 1982; Fox & Mathews, 1981). Fast twitch fibers show the greatest amount of hypertrophy in response to a weight training program (Fox & Mathews, 1981).

Muscular strength can be increased by a variety of training methods. Walderman & Stull (1969) used a training program of high repetitions and low intensity resistance training over eight weeks and found a significant ($p < .05$) increase in strength. This type of training program produced a greater improvement in muscular endurance than strength although both were significantly increased. Berger (1962) and Berger (1963) studied the effects of three different weight training programs with a frequency of three days per week for eight to 12 weeks. Three groups combined different numbers of sets and repetitions to determine optimal training loads for maximal strength gains. Clarke & Stull (1970) and Stull & Clarke (1970) found that both the strength and muscular endurance were developed equally using either a low repetition, high load or high repetition, low load program.

Biochemically the muscle cell responds to strength training with the transition of fast oxidative flycolytic (FOG) cells to fast glycolytic (FG). Goldberg (1968) found an increase in muscle weight proportional to the increase in amino acids in the muscle cell. In training using a bicycle ergometer Gollnick et al (1973) found increases in the percentage are of slow twitch fibers when subjects trained for endurance purposes. The oxidative capacity for both fiber types increased significantly ($p < .01$) from pretraining measurements. Gollnick (1972) found that fiber type differed in men according to the type of training or sport in which they engaged. Fast twitch fibers were dominant in the group which trained anaerobically. They also found an increase in succinate dehydrogenase (SDH) levels of those subjects who were endurance trained.

Body Composition

Discussion of body composition is simplified when total bodu weight is divided into fat weight and lean weight. Training can affect each component concurrently.

Wilmore (1974) found decreases in fat weight and significan increases in lean body weight (LBW) in men and women after a 10 week training program of weight lifting. The increase in LBW was due to an increase in muscle mass. Wallace (1975) found a decrease in fat weight in college age women participating in moderate aerobic and weight training exercises after four months of training Pollock, Cureton & Grenniger (1974) found similar changes occur with endurance exercises. Pollock found decreases of six to eight pounds of fat and increases of two to three pounds of LBW during a jogging program. Pollock (1974) also found decreases in fat weight with varying modes of exercise including aerobic work, interval training and a combination of the two. Similar changes were observed by Boileau (1971) in adult men. Greater fat loss was noted in obese men when compared to lean men. This was probably due to the increased potential for loss by the former.

Comparison of the Male and Female Response to Training

Regarding strength, the difference between males and females lies in the females lower strength to body weight ratio. When expressed in terms of total body weight the female is generally 30 percent weaker mostly in upper body strength than their male counterparts (Wilmore, 1974; Hettinger, 1961). The difference is less pronounced when body weight is expressed in terms of LBW. Wilmore (1974) found that leg strength in females was equivalent or slightly better than male's when expressed in terms of LBW. The female response to weight training (i.e., percent gain) does not differ from that of the male except in terms of absolute strength gains as demonstrated by Wilmore (1974).

The female response to endurance training foes not differ from that of the male. The American College of Sports Medicine (1980) makes no distinction between sexes in their guidelines for endurance training methods (i.e., frequency, intensity or duration). Drinkwater (1973) has reported the female response to training to be very similar to that of men is regards to their physiological changes in HR max and $\dot{V}O_2$ max. When $\dot{V}O_2$ max values are expressed in terms of LBW the difference is minimal, as little as five percent (Davies et al, 1972). However, the female is at a disadvantage in most sports in terms of the extra adipose tissue that is carried. In swimming events this extra adipose tissue may be an advantage. This contentions is supported by the smaller differences in performances between male and female swimmers as compared to running.

The difference in body composition between males and females is substantial especially when discussing athletic performances and mechanical advantages. If the average female and male adult are compared, the female is typically three to four inches shorter, 25-30 pounds lighter in total body weight, 10-15 pounds heavier in adipose tissue and 40-45 pounds lighter in terms of Free Fat Weight (FFW) (Fox & MAthews, 1981). When comparing the athletic female on a similar scale, she is still only at the level of the average non-athletic male (Fox & Mathews, 1981). Although the response to the varied training regimens is similar, the initial differences in body composition must be considered when comparing performances.

Physiological Changes During the Competitive Season

Research studying physiological changes in athletes through their competitive season is relatively scarece. Research that has been completed examined predominantly physiological variables such as $\dot{V}O_2$ max, HR max, percent body fat, muscular strength and muscular endurance and their changes over the course of a season. A variety of sports has been examined with both male and femal subjects at the collegiate and national level. Throughout the research, the high level of conditioning year round of each of these populations and the relatively small changes in these physiological variables seems related. This is particularly true in the research of Hanson (1970). He measured the U.S. Nordic Ski Team pre- peak- and post-season. Body composition remained stable and there were small increases in $\dot{V}O_2$ max ($l \cdot min^{-1}$) scores although not significant. Significant physiological changes occured in $\dot{V}O_2$ max ($ml \cdot kg^{-1} \cdot min^{-1}$) at the time these athletes changed from dry land training to snow training and the competitive season. Hanson mentioned the increase in travel and competition which decreased the amount of time available to train as a possible factor affecting the variables.

Kelly, Gorney & Kalm (1978) investigated cardiovascular fitness and body composition changes using collegiate wrestlers. They found that body composition, $\dot{V}O_2$ max anthropometric measurements, percent body fat and lean body weight remained relatively stable throughout the season. Strength measurements of knee extension at 180°/second, shoulder extension at 30°/second, and shoulder extension, knee flexion, knee extension and hip flexion at 180°/ second all increased significantly during the season. These measurement were done pre- peak- and post-season over six months.

Green & Huston (1975) studied seasonal changes in ice hockey players. They evaluated $\dot{V}O_2$ max, HR max and skinfold thickness' as well as anaerobic alactacid power. They found all variables changes very little except the anaerobic power measurements. This is logical in light of the anaerobic nature of the sport and the specificity of training.

McArdle, Magel & Kyvallos (1971) investigated the physiological changes of women basketball players through a three month season. They found no significant changes in $\dot{V}O_2$ max or HR max. Sinning & Adrian (1968) examined 17 female basketball players through a two month season of six person basketball.

They found a significant increase in $\dot{V}O_2$ max. In a similar study by Sinning (1973), 14 female basketball players using a fiver person game were evaluated. Significant increases in $\dot{V}O_2$ max $(ml \cdot kg^{-1} \cdot min^{-1})$, $(ml \cdot kgLBW^{-1} \cdot min^{-1})$ LBW and body weight were found. Mean $\dot{V}O_2$ max values for the studies previously mentioned are as follows: 35.5 $(ml \cdot kg^{-1} \cdot min^{-1})$, 44.8 $(ml \cdot kg^{-1} \cdot min^{-1})$, 34.3 $(ml \cdot kg^{-1} \cdot min^{-1})$ for McArdle, Magel & Kyvallos (1971), Sinning (1973), and Sinning & Adrian (1968) respectively.

Extensive comparisons of men and women in similar sports have not been made. Recent information points to the importance of anaerobic power in sports such as basketball, volleyball and football (Conlee, McGowan, Fisher, Dalsky & Robinson, 1982; Green & Huston, 1975). Specificity of training is an important concept by which athletic teams are trained. The measurement of these training programs needs to be as specific as possible to the different energy systems being used in that activity.

CHAPTER IV

METHODS

Description of Subjects

Subjects were nine female and four male members of the University of Nebraska at Omaha basketball teams. Subjects and legal guardians read and signed an informed consent form which was approved by the Institutional Review Board of the University of Nebraska.

Description of Treatment

Subjects trained and competed as members of the University of Nebraska at Omaha (UNO) men's and women's basketball teams. All subjects followed similar training programs. Supervised practices began the first week of October. Practices included seven to 10 minutes of static stretching by the men's team and 15 minutes of Proprioceptive Neuromuscular Facilitation techniques by the women. Each was designed to maintain and/or enhance flexibility. The next 70 to 90 minutes were devoted to skill and strategy work to develop the aerobic and anaerobic conditioning of each group. This skill/strategy work comprised the majority of most practice sessions. It was followed by a 15 minute period of specific conditioning work for the anaerobic system, usually consisting of half and full court sprints with timed rest intervals. Following the women's practice, a light period of cooldown stretches were done. The men had no structured cooldown. Resistance training occured three times per week in October. This was a three sets of 10 repetition program at 65-75 percent of a one repetition maximum. The program was designed for upper and lower extremity strengthening. During the competitive season the same resistance training program was decreased to one day per week and was often missed due to facility scheduling difficulties.

Each team was limited to 28 games by the National Collegiate Athletic Association. The men's team did advance to regional tournament play and had two additional games. The length of the season was 22 and 24 weeks for the women's and men's teams respectively. The training program is typical of most college basketball teams as it is designed to build cardiorespiratory fitness, muscular endurance and to refine skills and tactics via a supervised weight training and aerobic training program as well as scrimmages and drills.

Testing Procedures

$\dot{V}O_2$ Max Test

Subjects underwent a treadmill test to determine maximal oxygen consumption ($\dot{V}O_2$ max) using open circuit spirometry. The test began at zero percent grade at three mph for three minutes. For stage two of the test the speed was increased to six mph for two minutes. The speed was then increased one mph every two minutes until and eight mph pace was reached for the females and nine mph for the males. At this point the pace was kept constant and the percent grade was increased two percent every two minutes. This procedure was continued until the subject reached exhaustion. Exhaustion was determined by the following criteria: 1) subject was within 10 beats per minute of estimated maximal heart rate (220 - age), 2) a respiratory exchanges ratio of 1.00 of greater was reached, 3) reduced coordination and dyspnea wereobserved. Inspired air was collected and measured using a Parkinson-Cowen LD-4 dry gas meter. A Beckman LB-2 carbon dioxide analyzer and Applied Electrochemistry S-3A oxygen analyzer were used to measure gas fractions. The analyzers were calibrated prior to each test using a known reference gas.

Lower Extremity Strength,Power and Muscular Endurance Tests

Subjects were measured for quadriceps and hamstring strength, power and muscular endurance using anCybex II Isokinetic Dynamometer. A Cybex II Dual Channel Recorder and Cybex Data Reduction Computer were used to collect data. The subjects were directed to warm-up with five minutes of light exercise followed by five minutes of lower extremity stretching concentrating on the quadricep, hamstring and gastocnemius muscles. They were then seated on a Cybex II Lower Extremity Testing Chair. Restraining belts were placed across the limb being tested and across the chest with the arms placed across the chest. One warm-up repetition at the testing speed was allowed before each test to familiarize the subject with the test speed. Three repetitions at 30, 90, 180, 240 and 300 degrees per second constituted the measures of strength and power. Peaque torque at 30^{o}/second was used for data on strength. All data were expressed in foot-pounds of work done. 15 seconds of rest were allowed between each trial.

Muscular endurance was measured using a 25 repetition work test at 180^{o}/ second. Subjects flexed and extended their knee joint for 25 repetitions. The subjects score consisted of foot-pounds of work for the first five repetitions which constituted the power measurement and the total work done was the measure of muscular endurance. The subjects began each testing session with the tests for strength and ended with the 25 repetition work test.

Hydrostatic Weighing

Total body volume and density were determined using hydrostatic weighing Body density was converted to percent body fat using the Siri equation (Wilmore, 1982). Subjects were seated in a chair suspended from a Chatillon Autopsy Scale in a hydrostatic weighing tank. Underwater weight of the subjects were measured after the subject had performed maximal expiration and were totally submerged. Seven to 10 trials were performed by each subject to account for the learning effect associated with this procedure. The mean of the three most similar and heaviest values were averaged to determine underwater body weight. Residual volume was estimated based upon the age, height and sex of the subject

Statistical Treatment

1. A correlated t-test was used to determine within group changes.
2. An independant t-test was used to determine between group changes
3. An alpha level of .05 was used to describe statistical significance.

CHAPTER V

RESULTS

The purpose of this study was to examine and compare the cardiorespiratory fitness, muscular strength, muscular endurance and body composition of male and female collegiate basketball players over the course of a season. A general description of each group is presented in Table 1. Nine women and four men completed the entire testing series. All were members of the University of Nebraska at Omaha basketball teams.

Within Group Changes

Cardiorespiratory Fitness

Pre- and post-season data for the men's and women's teams can be found in Tables 2 and 3. A correlated t-test was used to determine within group changes. Significant differences were found in $\dot{V}O_2$ max $(l \cdot min^{-1})$ $(ml \cdot kg^{-1} \cdot min^{-1})$ $(p=.05)$ for the women. The men's team had a significant $(p=.05)$ change only in $\dot{V}O_2$ max $(l \cdot min^{-1})$.

Muscular Strength

Muscular strength was measured for both the quadriceps and hamstring muscle groups. Peak torque at 30^{o}/second was used to measure muscular strength. These data represented in Tables 4 and 5 for the women and men respectively. No significant changes were found in any variable for either group. There was a trend toward decrease in mean strength measures for both muscle groups in the women while the men had a decrese in quadriceps strength and an increase in hamstring strength.

Muscular Power and Muscular Endurance

Muscular Power was assessed using the Cybex II Isokinetic Dynamometer integrated with a Cybex Data Reduction Computer. A 25 repetition work test of the lower extremity at 180^{o}/ second was used. Mean torque for the first five repetitions and total work of the quadricep and hamstring muscles over 25 repetitions constituted measures of muscular power and endurance respectively. Tables 6 and 7 present this data. All data are expressed in foot-pounds of work. No significant changes were found in any variable for either group. The women did show a trend toward increases in both measures while the data on the men revealed no consistant movement either up or down. Their data seemed more tied to the extremity tested and did not follow a pattern.

Body Composition

Tables 8 and 9 contain the data describing the body composition changes of the subjects. No significant changes were found for either the men or women in any of the variables.

Between Group Changes

Table 10 contains data describing the changes between the groups. In the measures of muscular strength there was a significan (p=.05) decrease in left quadricep strength and a significant (p=.01) decrease in right quadricep, left and right hamstring strength in the women's team. There were no other significant changes found in this comparison of the groups but there was an upward direction in the measures of cardiorespiratory fitness as would be expected with the significant increases found in within group comparisons described previously.

Table 1

General Descriptors of Subjects (mean ±)

Variable	Females (n=9)		Males (n=4)	
	pre	post	pre	post
Age (yr)	19.9 ± 1.2	20.3 ± 1.3	20.25 ± 0.5	20.5 ± 0.6
Height (cm)	177.1 ± 8.2	176.7 ± 8.01	195.75 ± 12.8	195.8 ± 12.8
Weight (kg)	71.8 ± 10.7	72.4 ± 10.7	94.48 ± 8.21	94.7 ± 8.9

Table 2

Cardiorespiratory Data for Women's Team (mean $\pm$ SD) (n=9)

	pre $\pm$ SD	range	post $\pm$ SD	range	t-ratio
$\dot{V}O_2$ max ($ml \cdot kg^{-1} \cdot min^{-1}$)	44.87 $\pm$ 4.09	40.07 - 50.59	49.24 $\pm$ 4.37	43.41 - 34.80	-2.13*
$\dot{V}O_2$ max ($l \cdot min^{-1}$)	3.19 $\pm$ 0.35	2.62 - 3.67	3.55 $\pm$ 0.37	2.94 - 2.96	-2.20*
$\dot{V}E$ max BTPS ($l \cdot min^{-1}$)	110.17 $\pm$ 11.20	100.29 - 124.64	111.63 $\pm$ 11.40	94.71 -132.94	- .28
$\dot{R}$	1.11 $\pm$ .068	1.01 - 1.20	1.14 $\pm$ .37	1.03 - 1.22	- .94
Time to Exhaustion (min)	12.06 $\pm$ 1.59	10.5 - 15.0	12.75 $\pm$ 2.24	10.0 - 16.5	- .70

* $p < .05$

Table 3

Cardiorespiratory Data for Men's Team (mean $\pm$ SD (n=4)

	pre $\pm$ SD	range	post $\pm$ SD	range	t-ratio
$\dot{V}O_2$ max ($ml \cdot kg^{-1} \cdot min^{-1}$)	52.62 $\pm$ 3.91	47.24 - 53.86	58.05 $\pm$ 4.47	52.95 - 61.29	-1.26
$\dot{V}O_2$ max ($l \cdot min^{-1}$)	4.87 $\pm$ .32	4.43 - 5.17	5.33 $\pm$ .25	5.07 - 5.57	-1.75*
$\dot{V}E$ max BTPS ($l \cdot min^{-1}$)	147.65 $\pm$ 8.61	139.57 - 155.93	57.27 $\pm$ 15.6	141.13 - 172.37	-1.06
$\dot{R}$	1.07 $\pm$ .09	.95 - 1.15	1.16 $\pm$ .02	1.14 - 1.18	-1.73
Time to Exhaustion (min)	15.66 $\pm$ 1.15	15.0 - 17.0	16.80 $\pm$ 2.25	14.50 - 19.00	- .80

* $p < .05$

Table 4

Muscular Strength for Women's Team (mean ± SD) (n=9)*

	pre ± SD	range	post ± SD	range	t-ratio
Left Quadriceps	133.44 ± 16.8	112 - 166	126.00 ± 24.8	94 - 170	.947
Right Quadriceps	135.78 ± 17.7	108 - 156	127.56 ± 19.6	95 - 145	1.16
Left Hamstring	93.22 ± 14.2	69 - 112	90.11 ± 12.3	73 - 108	.50
Right Hamstring	92.11 ± 13.9	68 - 119	89.56 ± 19.0	63 - 125	.32

*measured in foot-pounds

Table 5

Muscular Strength for Men's Team (mean ± SD) (n=4)*

	pre ± SD	range	post ± SD	range	t-ratio
Left Quadriceps	214.00 ± 34.5	186 - 259	202.33 ± 16.90	188 - 221	0.53
Right Quadriceps	206.00 ± 22.8	178 - 232	206.67 ± 7.64	200 - 215	-0.05
Left Hamstring	120.75 ± 22.7	106 - 157	139.00 ± 16.40	121 - 153	-0.53
Right Hamstring	136.25 ± 23.3	111 - 156	143.33 ± 12.70	136 - 158	-0.47

*measured in foot-pounds

Table 6

Muscular Power and Endurance for Women's Team (mean ± SD) (n=9)*

	pre ± SD	range	post ± SD	range	t-ratio
Muscular Power Left Side	911.00 ± 100.0	788 - 1073	920.89 ± 125.0	718 - 1114	-0.185
Muscular Power Right Side	877.33 ± 170.0	554 - 1118	882.33 ± 136.0	655 - 1073	-0.069
Muscular Endurance Left Side	3708.60 ± 371.0	3117 - 4270	3754.60 ± 430.0	3241 - 4280	-0.252
Muscular Endurance Right Side	3430.40 ± 683.0	1913 - 4195	3686.10 ± 586.0	2957 - 4287	-0.852

*measured in foot-pounds

Table 7

Muscular Power and Endurance for Men's Team (mean ± SD) (n=4)*

	pre ± SD	range	post ± SD	range	t-ratio
Muscular Power Left Side	1465.00 ± 111.0	1301 - 1563	1450.30 ± 84.7	1319 - 1510	-0.113
Muscular Power Right Side	1435.80 ± 124.0	1304 - 1555	1446.00 ± 110.0	1398 - 1548	0.190
Muscular Endurance Left Side	5832.80 ± 541.0	5112 - 5412	6118.70 ± 631.0	5409 - 6618	-0.647
Muscular Endurance Right Side	5834.50 ± 485.0	5128 - 6164	5808.00 ± 475.0	5403 - 6331	0.072

Table 8

Body Composition Data for Women's Team (mean ± SD) (n=9)

	pre ± SD	range	post ± SD	range	t-ratio
Weight (kg)	71.79 ± 10.70	54.91 - 90.70	72.38 ± 10.60	54.60 - 91.30	-0.12
Lean Body Weight (kg)	56.07 ± 6.70	44.91 - 67.98	59.80 ± 5.87	45.45 - 67.40	-1.25
Density	1.0524 ± .0099	1.04 - 1.07	1.0522 ± .00913	1.04 - 1.07	.05
Percent Body Fat	21.44 ± 4.86	13.04 - 29.18	20.61 ± 4.21	14.91 - 26.18	.39

Table 9

Body Composition Data for Men's Team (mean ± SD) (n=4)

	pre ± SD	range	post ± SD	range	t-ratio
Weight (kg)	94.47 ± 8.21	82.20 - 99.50	94.67 ± 8.99	82.70 - 102.10	-0.03
Lean Body Weight (kg)	84.98 ± 6.72	75.30 - 90.70	84.11 ± 6.41	76.20 - 91.02	-0.19
Density	1.0820 ± .00725	1.07 - 1.07	1.0743 ± .00669	1.07 - 1.08	1.44
Percent Body Fat	9.93 ± 2.66	7.06 - 12.60	11.18 ± 3.00	7.92 - 14.62	.63

Table 10

Comparison in the Changes Between Groups
(men, n=4, women, n=9)

Variable	Pre-Post Changes in Females	Pre-Post Changes in Males	Independent t-ratio
$\dot{V}O_2$ max ($ml \cdot kg^{-1} . min^{-1}$)	4.0	6.7	1.023
$\dot{V}O_2$ max ($l \cdot min$)	.6	.4	1.945
$\dot{V}E_{BTPS}$	.7	6.9	.993
$\dot{R}$	.05	.02	1.023
Time to Exhaustion (min)	.68	2.17	1.062
Left Quadricep*	-9.4	3.3	1.851[1]
Right Quadricep*	-8.2	5.7	2.641[2]
Left Hamstring*	-3.1	17.0	2.489[2]
Right Hamstring*	-2.6	13.7	3.487[2]
Muscular Power - Left*	18.6	-37.0	.270
Muscular Power - Right*	17.2	-6.0	.112
Muscular Endurance - Left*	46.0	117.7	.479
Muscular Endurance - Right*	255.7	-1.7	-.746
Weight (kg)	-.65	.59	-.718
Lean Body Weight (kg)	-.87	1.16	-.76
Density	-.0008	.0188	-1.317
Percent Body Fat	-.9444	1.268	1.230

[1] $p < .05$
[2] $p < .01$
* ft-lbs

CHAPTER VI

DISCUSSION

Within Group Changes

Cardiorespiratory Changes

Significant ($p=.02$) pre-post season changes were found in VO_2 max ($l\ min^{-1}$) ($ml\ kg^{-1}\ min^{-1}$) in the femalws. Nearly significant changes ($p=.07$) pre-post season changes were found in the males' VO_2 max ($ml\ kg^{-1}\ min^{-1}$). A significant ($p=.04$) change was found in VO_2 max ($l\ min^{-1}$). Changes in VO_2 max ($ml\ kg^{-1}\ min^{-1}$) although not significant, did follow a pattern similar to the females. The lack of significance could possibly be due to the smaller sample size (N=4) a higher initial fitness level, and a 40 percent increase increase in percent body fat.

Previous research using competitive athletes over a season as well as training studies using male and female subjects found similar significant changes in VO_2 max scores (Drinkwater, 1973; Ekblom et al, 1968; McArdle, Magel & Kyvallos, 1971; Michael, Evert & Jeffers, 1972; Sinning, 1972, Sinning & Adrian, 1968).

Mean VO_2 max ($ml\ kg^{-1}\ min^{-1}$) dcores for athletes in this study ($x=44.87$) compared favorably with those of other studies for female basketball players: 44.8, 34.4, 35.5 for Sinning, 1972; Sinning & Adrian, 1968; and McArdle, Magel & Kyvallos, 1971 respectively.

Muscular Strength

No significant changes were found with either the male or female samples in any strength measurements. There was however, a seven and six percent decrease in left quadriceps strength, respectively, in the female players. In the male athletes there was a six percent decrease in left quadriceps strength while all other variables remained stable or slightly increased. The women showed no increase in any strength measurement.

Wilmore (1974) and Mayhew & Gross (1975) showed subjects improved strength with training designed to improve strength. Each basketball team's training was designed not to increase strength, but rather to maintain it. The bilateral strength decrease in the females and a similar pattern in the smaller male sample are interesting trends.

Previous research of Burkett (1970), Laird (1981) and Wilkerson, Martin & Sparks (1980), have shown that a quadriceps ratio of 60 percent is an important level in preventing muscle pulls. There is increase risk that the stronger quadriceps muscles can overpower the hamstring muscles during explosive activities and result in muscle pulls if this ratio is less than 60 percent. In addition to this fact is the trend toward higher ratios as the speed of the limb motion is increased. Table 11 shows that both samples substantiated previous research. The females higher ratio is not necessarily due to higher levels of hamstring strength as much as low levels of quadriceps strength. This could be due to the less powerful nature of women's basketball as compared to men's. A more explosive game would require greater quadricep development (i.e. for the jumping).

Muscular Power and Endurance

Previous research over the course of a season of competitive basketball season has not included measures of muscular power and endurance as descriptive statistics. One would assume that the anaerobic nature of basketball as described by some authors (de Vries, 1980; Fox & Mathews, 1981) would produce changes in these measures over the course of a season. However, the data fail to show any changes in muscular power as females and males showed only a one percent change in muscular power. Muscular endurance increased an average of four and one-half percent in females and three percent in males. None of these changes were statistically significant. The weight training program of both groups were not designed to increase either strength or muscular endurance but rather to maintain the levels at the beginning of the season.

The lack of significance could be due to the nature of the test. A 25 repetition work test was used to determine muscular endurance. The phosphagen system is not taxed with this test. The small sample size could also have been a contributing factor to the lack or significance as well as the initial fitness levels of the subjects.

Body Composition

Although no significant changes were found in measures of body composition, an increase (p=.11) in female lean body weight and male density (p=.10) were found. In this study the small sample size as well as the athletes competitive participation and injury status could have contributed to the lack of significance. Two female athletes were academiclly ineligible and one male athlete had an ankle injury during the course of the season.

Previous research of Sinning (1973) found significant increases in lean body weight and tital body weight of female basketball players.

No other research with female basketball players found significant changes in these variables. This could be due to the year round nature of the athletes conditioning and the already lean body composition of these competitive athletes compared to the 1973 study.

Female athletes inthis study had a mean total body weight of 71 kg as compared to 61 kg for the subjects in McArdle, Magel & Kyvallos (1971) and Sinning & Adrian (1968). The length of the season for athletes in this study was five weeks longer than previous studies and involved longer and more frequent practice sessions.

Between Group Changes

Cardiorespiratory Changes

No significant changes were found between groups in any measures of cardiorespiratory fitness. The small sample size and high initial fitness levels could have contributed to the lack of significant change between groups.

Muscular Strength

Between group differences were found in all strength variables. In each case the females showed a significant decrease in strength as compared to the males population, right quadricep ($p=.01$), left quadricep ($p=.05$), right hamstring ($p=.003$), left hamstring ($p=.004$).

Previous research failed to measure lower extremity strength in seasonal studies of women basketball players. Both teams performed a minimal amount of strength training during the season. Wilmore (1982) found both men and women to be equally trainable. With this in mind, it may be the difference in the type of game played by the men and women, the men's game being a more powerful, explosive game and the women's being more prolonged with less explosive jumping.

Muscular Power and Endurance

No statistically significant differences were found between the groups. These results could be due to an initially high fitness level which leaves little room for improvement. The small sample size could also affect the statistical significance. A third possible reason could be the length of the test. A 25 repetition test for endurance lasts 25 seconds and may not be adequate in terms of the time span for measuring the endurance of basketball players. Fox & Mathews (1981) state that basketball is a sport 85 percent dependant upon ATP-CP and 15 percent dependant upon the lactic acid-oxygen system. Perhaps a longer test of muscular endurance would yield a greater change between pre- and post-season changes.

An observation of the training methods of both teams might have affeceted these variables in that the training is aimed at long-term progression of skills and not creating a "stale" athlete.

Body Composition

No statistically significant differences were found between the groups. This would be due to the small sample size and relatively high fitness level of both samples as well as the male increase in percent fat combined with a decrease in lean body weight. The female sample had an increase in lean body weight and decrease in fat weight.

TABLE 11

Average Quadricep/Hamstring Ration at Varying Speeds

Angular Velocity*	30	90	180	240	300
Female	71.3	76.2	82.3	89.8	93.5
Male	68.3	70.2	76.2	76.5	77.3

* expressed in degrees per second

CHAPTER VII

SUMMARY AND CONCLUSIONS

Summary

This study compared the physical fitness changes of male and female college basketball players over a competitive season. Basketball players at the University of Nebraska at Omaha practiced 2½ hours a day, 5 days a week for 22 weeks. They were involved in flexibility, strength, aerobic, anaerobic, and skill work designed to improve their playing abilities. Cardiorespiratory fitness, muscular strength, muscular power, muscular endurance, and body composition were assessed prior to and immediately after the competitive season.

Significant pre-post season changes in the female population were found in the following variables: $\dot{V}O_2$ max $(ml \cdot kg^{-1} min^{-1})$ (p=.01) $\dot{V}O_2$ max $(l \cdot min^{-1})$ (p=.05). The only significant change the males experienced was $\dot{V}O_2$ max $(l \cdot min^{-1})$ (p=.05).

Significant between group changes were found in the females in the following variables: significant decreases in left quadriceps (p=.05), right quadriceps (p=.01), left hamstring (p=.004), right hamstring (p=.003) in females.

Conclusions

Based on the results of this study, the following conclusions can be drawn regarding the physical fitness changes in male and female college basketball players over a competitive season at the University of Nebraska at Omaha:

1. Cardiorespiratory fitness

   Basketball practices were able to produce a signigicant increase in $\dot{V}O_2$ max ($ml \cdot kg^{-1} \cdot min^{-1}$ and $l \cdot min^{-1}$) in both male and female basketball players.

2. Muscular strength

   a. Muscular strength was not changed significantly over the course of a competitive season in either group.

   b. Significant differences were found between groups in all measures of quadricep and hamstring strength with the females haveing decreased over the competitive season.

3. Muscular power and endurance

   No significant changes within each group or differences between the groups wre found.

4. Body composition

   No significant changes within each group or differences between each group were found.

Recommendations

There is a need for further study on seasonal changes in similar sports performed by males and females. The following recommendations for further study can be made based upon this study:

1. A larger sample size should be used.
2. An additional measure of anaerobic power other than the Cybex 25 repitition work test should be used which would be a more valid indicator of the lactic acid and alactacid energy systems.

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APPENDIX

University of Nebraska at Omaha

School of Health, Physical Education & Recreation
University of Nebraska at Omaha□Omaha, NE 68182

Subject Informed Consent Form
Comparison of Physical Fitness Changes in Male and Female College Basketball Players and the Relationship to Injury

You are invited to participate in a project in which we are studying the fitness changes of basketball players and the relationship to injury. You will be asked to participate in a pre and post test treadmill run, underwater weighing, muscular strength and endurance test, bicycle test and flexibility test.

You will allow Dr. Kris Berg, Denise Fandel and other lab assistants to administer the following tests:

Methods

Running Test On a Treadmill. A treadmill is a machine which lets a person run indoors. You will be asked to run on this machine until you are tired and wish to stop. This will feel like running up a large hill. At the end of the test you will feel tired, your heart will be beating fast and you will be breathing rapidly and deeply. We will cheer you on to run as long as you can; you can stop at any time you wish by pushing the "stop" button or grabbing the rails. We will not be upset with you for stopping anytime you wish. During the running you will breathe through a special mouthpiece and some plastic tubing and we will measure your heart rate. You will take this test on 2 separate occasions.

Body Fat. We will find out how much fat is in your body by weighing you underwater. You will be dressed in a swim suit and then sit in a chair hanging from a scale in a small pool. The pool will contain clean, warm water. You will put your head and face under the water, blow out air and hold your breath for a few seconds. Anytime you want you may take your head out of the water.

Breathing Test. You will force out as much air as you can into a device (spirometer) which has a tublar mouth piece. This data will be used in computing your body composition.

Bicycle Test. You will be asked to pedal as hard and fast as you can for 30 seconds on a stationary bicycle. The resistance you pedal against will be adjusted to your body weight. At the end of the test you will feel tired your heart will be beating rapidly and you will be breathing deeply. Your legs will feel heavy and very tired. You will be asked to take this test on 2 separate occasions.

Muscle Strength and Endurance Test. You will be seated in a chair and your leg will be held down using a Velcro strap. You will be asked to bend and straighten you leg as fast as possible. The machine will control how fast you move. You will be asked to do three repetitions at five different speeds. You will also be asked to bend and straighten your leg continually for thirty seconds. Your legs will feel tired and heavy.

Flexibility Tests. You will be asked to perform five tests that will be used to predict possible injury. You will be asked to 1) touch the palms of hands to the floor; 2) stand with your knees completely straight; 3) stand with your heels together and rotate your ankles so your toes point to the side as far as possible; 4) sit on the floor and try to put your heels on the opposite thigh; 5) stand with your arm in front of you completely extended and palms facing up.

Understand that you may drop out of this project any time you wish without hurting your relationship with us or the University of Nebraska. We will provide a written copy of all your test results and results of the total group and will also explain them to you. No one but you and the investigators and your coaches will have access to your test scores.

Risks and Discomforts

During the treadmill test, you will be breathing deeply and rapidly, sweating and your heart will be beating rapidly. Your leg muscles may ache during the last several minutes of the test but this pain will rapidly diminish within 5 to 10 minutes upon completing the test. There may be some muscle soreness a day or two following the treadmill test and the strength tests.

If injury occurs as a direct consequence of these procedures, the emergency medical care required to treat the injury will be provided at the University of Nebraska at no expense to you, providing that the cost of such medical care is not reimbursable through your own health insurance. However, no additional compensation for medical care, hospitalization, loss of income, pain, suffering, or any other form of compensation will be provided as a result of such injury.

All testing will be performed at the University of Nebraska at Omaha Exercise Physiology Laboratory. All four visits will last approximately one hour. You will be treadmill tested, flexibility tested and underwater weighed in the same session. Muscle strength and endurance tests will be given in the same session as the bicycle test.

Participation is voluntary. Your decision whether or not to participate will not affect your relationship with the University of Nebraska at Omaha. If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time.

Benefits

You will receive a pre and post assessment of your fitness level, body composition, muscle strength, endurance and flexibility as well as being informed of possible injury risk. If you show any risk of injury you will be rehabilitated in the University of Nebraska at Omaha Athletic Training Room.

YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE. YOUR SIGNATURE INDICATES THAT YOU HAVE DECIDED TO PARTICIPATE HAVING READ THE INFORMATION PROVIDED ABOVE. YOU WILL BE GIVEN A COPY OF THIS CONSENT FORM TO KEEP.

Subject's Signature ______________________________ Date____________

Witness ______________________________ Date____________

Investigator ______________________________ Date____________

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University of Nebraska at Omaha

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Parent Informed Consent Form
Comparison of Physical Fitness Changes
in Male and Female College Basketball
Players and the Relationship to Injury

Your son/daughter is invited to participate in a project in which we are studying the fitness changes of basketball players and the relationship to injury. He/she will be asked to participate in a pre and post test treadmill run, underwater weighing, muscular strength and endurance test, bicycle test and flexibility test.

You will allow Dr. Kris Berg, Denise Fandel and other lab assistants to administer the following tests:

Methods

Running Test On a Treadmill. A treadmill is a machine which lets a person run indoors. Your son/daughter will be asked to run on this machine until they are tired and wish to stop. This will feel like running up a large hill. At the end of the test they will feel tired, their heart will be beating fast and they will be breathing rapidly and deeply. We will cheer them on to run as long as they can; they can stop at any time they wish by pushing the "stop" button or grabbing the rails. We will not be upset with them for stopping anytime they wish. During the running they will breathe through a special mouthpiece and some plastic tubing and we will measure their heart rate. They will take this test on 2 separate occasions.

Body Fat. We will find out how much fat is in your son/daughter's body by weighing them underwater. They will be dressed in a swim suit and then sit in a chair hanging from a scale in a small pool. The pool will contain clean, warm water. They will put their head and face under the water, blow out air and hold their breath for a few seconds. Anytime they want they may take their head out of the water.

Breathing Test. Your son/daughter will force out as much air as they can into a device (spirometer) which has a tublar mouth piece. This data will be used in computing their body composition.

Bicycle Test. Your son/daughter will be asked to pedal as hard and fast as they can for 30 seconds on a stationary bicycle. The resistance they pedal against will be adjusted to their body weight. At the end of the test they will feel tired their heart will be beating rapidly and they will be breathing deeply. Their legs will feel heavy and very tired. They will be asked to take this test on 2 separate occasions.

Muscle Strength and Endurance Test. Your son/daughter will be seated in a chair and their leg will be held down using a Velcro strap. They will be asked to bend and straighten their leg as fast as possible. A Cybex II machine will control how fast they move. They will be asked to do three repetitions at five different speeds. They will also be asked to bend and straighten your leg continually for thirty seconds. Their legs will feel tired and heavy.

Flexibility Tests. Your son/daughter will be asked to perform five tests that will be used to predict possible injury. They will be asked to 1) touch the palms of hands to the floor; 2) stand with knees completely straight; 3) stand with heels together and rotate their ankles so their toes point to the side as far as possible; 4) sit on the floor and try to put their heels on the opposite thigh; 5) stand with their arm in front of them completely extended and palms facing up.

Understand that he/she may drop out of this project any time they wish without hurting his/her relationship with us or the University of Nebraska. We will provide a written copy of all your son's/daughter's test results and the results of the total group and will also explain them to him/her. No one but your son/daughter, the investigators and his/her coach will have access to your son's/daughter's test scores.

Risks and Discomforts

During the treadmill test, your son/daughter will be breathing deeply and rapidly, sweating and his/her heart will be beating rapidly. His/Her leg muscles may ache during the last several minutes of the test but this pain will rapidly diminish within 5 to 10 minutes upon completing the test. There may be some muscle soreness a day or two following the treadmill test and the strength test.

If injury occurs as a direct consequence of these procedures, the emergency medical care required to treat the injury will be provided at the University of Nebraska at no expense to your son/daughter providing that the cost of such medical care is not reimbursable through your own health insurance. However, no additional compensation for medical care, hospitalization, loss of income, pain, suffering, or any other form of compensation will be provided as a result of such injury.

Participation is voluntary. Your son's/daughter's decision whether or not to participate will not affect his/her relationship with the University of Nebraska at Omaha. If he/she decides to participate, he/she is free to withdraw his/her consent and to discontinue participation at any time.

Benefits

Your son/daughter will receive a pre and post assessment of his/her fitness level, body composition, muscle strength, endurance and flexibility as well as being informed of possible injury risk. If he/she shows any risk of injury he/she will be rehabilitated in the University of Nebraska at Omaha Athletic Training Room.

YOU ARE MAKING A DECISION WHETHER OR NOT TO ALLOW ____________________ (NAME OF MINOR) TO PARTICIPATE. YOUR SIGNATURE INDICATES THAT, HAVING READ THE INFORMATION PROVIDED ABOVE, YOU HAVE DECIDED TO PERMIT ______________________________ (NAME OF MINOR) TO PARTICIPATE. THE SECOND COPY OF THIS FORM IS FOR YOU TO KEEP.

____
Signature

____
Date

____
Relationship to Subject

____
Witness (if required)

____
Signature of Investigator

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