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Peak isokinetic torque of knee flexors and extensor muscles of college football players

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PEAK ISOKINETIC TORQUE OF KNEE FLEXORS AND EXTENSOR MUSCLES OF COLLEGE FOOTBALL PLAYERS

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by

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CHAPTER 1

Introduction

Murphy (1978) identified knee injuries as the major reason for limiting or ending a football career. Buckley and Powell (1982) recognized the knee joint as the most frequently injured in football. Knee injuries required more time lost from participation, and resulted in more surgical repair than any other joint in the body.

Prevention of knee injuries became a priority to sports medicine personnel. Campbell (1982) indicated increases in strength and power influenced the ligaments and tendons around a joint. The maintenance or improvement of physical condition aids in the prevention of knee injuries by assisting in the muscular stability of the knee joint.

Bracing the knee has become a popular method of supporting the knee in hopes of injury prevention. Nwaobi (1980) examined knee stability of braced and taped knees. The results indicated that bracing the knee was more effective than taping at maintaining medial stability of the knee.

Sapega (1981) cited pre-participation screening as a primary means of preventing knee injury. Screening identifies strength, power and the balance of antagonist muscle groups. Davies (1984) stated isokinetic testing has allowed researchers to examine the dynamics of contracting

muscle through the range of motion.

To date the studies published have examined college football players in pre-participation examinations. Results from these studies have helped in the identification of those who have muscular deficiencies which may predispose them to injury of the knee. However, insufficient information exists to answer the question, "How does participation in college football affect the musculature surrounding the knee?" The need for the study, therefore, was to examine if participation in college football affects measures of dynamic strength and power of the musculature of the knee.

Statement of the Problem

The problem of the study addressed knee injuries in college football. Imbalance of the musculature surrounding the knee would predispose the athlete to knee injury. Recognition of those who have muscular deficiencies would be a primary way of preventing knee injuries. The focus of the study was to determine if there was a significant difference in peak isokinetic torque of knee flexor and extensor muscles across speeds (60 degrees/second, 180 degrees/second and 300 degrees/second) of a college football team subsequent to participation in a spring football season.

Subproblems

The following subproblems of the study were examined:

1. To determine if a significant difference existed in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds of offensive college football players subsequent to participation in spring football.

2. To determine if a significant difference existed in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds of defensive college football players subsequent to participation in spring football.

3. To determine if a significant difference existed in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds between offensive and defensive college football players subsequent to participation in spring football.

4. To determine if a significant difference existed in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds of skill position college football players subsequent to participation in spring football.

5. To determine if a significant difference existed in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds of linemen college football players subsequent to participation in spring football.

6. To determine if a significant difference existed in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds between skill position players

and linemen college football players subsequent to participation in spring football.

All subproblems of the study examined the following relationships:

a. Knee flexors and extensors across speeds.
b. The hamstring/quadricep ratio (H/Q) across speeds.
c. The quadricep/weight ratio (Q/W) across speeds.
d. The fast quadricep/slow quadricep ratio (FQ/SQ = 300/60 degrees/second).

Importance of the Study

The study compared the difference of pre and post measures of peak isokinetic torque of college football players participating in spring football. The importance of the study was to determine if significant differences existed in the knee musculature subsequent to participation in spring football. Disparities in isokinetic torque of the knee musculature may predispose an athlete to a knee injury. If significant differences exist, then coaches could reconsider the overall impact of training programs on knee musculature of the athlete during participation.

Hypotheses

The following hypotheses have been stated in null form:

1. There will be no significant difference in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds of a college football team subsequent to participation in spring football.

2. There will be no significant difference in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds of the offensive college football players subsequent to participation in spring football.

3. There will be no significant difference in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds of defensive college football players subsequent to participation in spring football.

4. There will be no significant difference in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds between the offensive and defensive college football players subsequent to participation in spring football.

5. There will be no significant difference in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds of skill position college football players subsequent to participation in spring football.

6. There will be no significant difference in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds of linemen college football players subsequent to participation in spring football.

7. There will be no significant difference in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds between skill position and linemen college football players subsequent to participation in spring

football.

Assumptions

The following assumptions were made to facilitate a better understanding of the study:

1. Each player made maximal voluntary effort for every repetition of the test.

2. Fatigue was not a factor due to the short duration of the exercise bouts.

Delimitations

The following delimitations were made to facilitate a better understanding of the study:

1. Subjects were returning University of the Pacific football players participating in the 1986 spring football season.

2. Test of muscle groups was limited to knee flexors and extensors.

3. Peak isokinetic torque at speeds of 60 degrees/second, 180 degrees/second and 300 degrees/second were tested.

4. Players with recent knee injuries and not participating in spring football were excluded from the study.

Limitations

Limitations related to subject mortality and study

methodology were noted as follows:

1. Seventy-six returning University of the Pacific football players were screened in the pre-test. Twenty-three players did not complete the post-test, leaving 53 players on which the results were based (70% of the initial sample). Of the 23 players who did not complete the post-test, four simply failed to meet the post-test commitment, five retired from football without completing spring football, and fourteen sustained injuries that eliminated them from spring football.

2. Cybex protocol was followed for the stabilization of the body and the knee, and for the alignment of the anatomical axis of the knee with the mechanical axis of the dynomometer. The researcher observed a discrepancy in the alignment of the two axes during testing. When the lower shank was extended the hip flexed, compressing the quadricep muscle up against the restraining strap. The small degree of hip flexion changed the relationship of the anatomical axis to the mechanical axis of the dynomometer. The same was true when the lower shank was flexed, the hip was extended, compressing the hamstrings against the padded table. The compression of the hamstrings and the padding allowed a change of the anatomical axis. This discrepancy of the relationship between the two axes was a limitation of the instrument, and should be considered a constant error.

3. During the spring football season the researcher was not able to control activity outside of practice. There was no scheduled weight training for the football team, but a few individuals chose to maintain their weight training, which might have influenced post-test measures.

Definition of Terms

The following terms were defined in order to facilitate a better understanding of the study:

Cybex II - Cybex II is an isokinetic dynomometer used to apply isokinetic resistance

Cybex Dual Channel Recorder - Cybex Dual Channel Recorder is an instrument when coupled with the Cybex II records isokinetic torque through joint range of motion

Fast Quadricep/Slow Quadricep Ratio (FQ/SQ) - Fast Quadricep/Slow Quadricep Ratio (FQ/SQ) is the ratio between the peak isokinetic torque of the quadriceps at 300 degrees/second and 60 degrees/second

Hamstring/Quadricep Ratio (H/Q) - Hamstring/Quadricep Ratio (H/Q) is the ratio between the peak isokinetic torque of the hamstring and the quadricep at the same speed

Isokinetic - Isokinetic refers to speed specific accommodating resistance

Isometric - Isometric refers to force applied without joint motion

Isotonic - Isotonic refers to force applied with constant resistance

Peak Isokinetic Torque - Peak Isokinetic Torque is the greatest torque achieved during a bout of isokinetic exercise

Power - Power is the amount of force applied in a given time period, isokinetically a speed greater than 60 degrees/second

Quadricep/Weight Ratio (Q/W) - Quadricep/Weight Ratio (Q/W) is the ratio between the quadriceps peak isokinetic torque and the body weight

Skill Position Players - Skill Position Players are the group of players who play offensive back and receiver, or defensive linebacker and defensive back

Spring Football - Spring Football is a unique season to college football that is limited to twenty practices over thirty days

Strength - Strength is the ability to apply force, isokinetically 60 degrees/second or less

Torque - Torque is the force applied around a joint axis; a product of rotational force and the length of the perpendicular lever arm

CHAPTER 2

Review of Related Literature

The review of related literature focused on three areas of discussion. The areas of discussion were the following: 1) knee injuries in college football and their effects on participation, 2) the value of isokinetic testing of college football players, and 3) previous studies of isokinetic torque measures of college football players.

Knee Injuries and Loss of Participation

Injury rates in college football have been widely examined. Following are several of the studies which are pertinent to this investigation.

Buckley and Powell (1982) and later Powell (1985) reported their findings in the National Athletic Injury/ Illness Reporting System (NAIRS). This epidemiological study followed college football programs that voluntarily chose to be part of the injury surveillance system. This eight year study provided information which reflected 395 team-seasons, or an average of 50 teams per season. Of this total, 74% were members of NCAA Division I schools.

The NAIRS data indicated that injury to the knee was the most common injury in college football. Knee injuries required more time loss from participation and more surgical repairs compared to any other joint. More specifically, the

medial collateral ligament was the most commonly involved structure in knee injuries, followed by the medial meniscus, and the anterior cruciate ligament. It was interesting to note that the game situation had an 8 or 9 times greater risk of injury than practice situations.

Whiteside et al. (1985) reported on injuries at Pennsylvania State University over a 12 year period (1972-1983). Again the data pointed out that knee injuries were the most numerous (485), and required the most days lost from participation (4,426). Another significant finding of the study was that knee injuries required more than double the days lost from participation than ankle injuries. The chance of injury to the knee per exposure was 0.49 in the spring season, and 0.33 in the fall, which implies that during the 20 consecutive days of contact during spring, a player is more susceptible to a knee injury. Also the defensive linebackers seemed the most susceptible to knee injuries as compared to other positions.

Murphy et al. (1978) examined the injury rate and time loss at Ohio State University over a five year period. As with the previous studies, the knee injury was the most common, resulted in the greatest amount of time loss, and required more surgeries than any other injury.

Canale et al. (1981) reported on Memphis State University from 1975 through 1979, a five year study which

examined the possibility of injury to an individual player. There were 283 injuries sustained by 265 athletes. The injuries were categorized by the amount of time lost from participation, where a mild injury resulted in less than one week, a moderate injury resulted in one to three weeks, and a severe injury was greater than three weeks lost from participation. Of the 283 injuries, 69% were mild, 20% were moderate, and 11% were severe. Again the knee was the most injured and required more loss of participation than any other area. The most interesting point of the study was that the probability of the individual being injured playing college football was 106.7% over a five year period, 99.1% over a four year period, and 46.6% for a one year player. The chance of an athlete having a severe injury over a five year period was 11.6%, a moderate injury 21.5%, and a mild injury 73.5%. Also knee injuries accounted for more severe injuries than all other classifications combined.

Summary The incidence of knee injuries in football are greater than any other injury, require more time lost from participation, and require more surgical repair than any other injury in football.

The Value of Isokinetic Testing in Football

Historically, athletes have typically been tested either

through competition or through specific objective testing for strength, flexibility, power, endurance, and other physiological parameters in an attempt to identify what traits or characteristics make up the successful athlete. Football, by nature of the game, desires athletes who are large, mobile, agile, and who can endure the physical punishment of the sport.

Wilmore et al. (1976) charted different physiological parameters to profile professional football players. The authors speculated that the better players were those who demonstrated the higher power values (strength/time) for their body size. By position, strength and power related to body size, with the exception of the defensive linebacker position. The linebacker, whose size falls between the offensive or defensive backs and the offensive or defensive linemen, demonstrated strength and power values similar to the larger linemen.

The introduction of isokinetic resistance in the late sixties gave the researcher another tool for testing. The concept of isokinetics allowed for resistance to be speed specific and accommodating. The researcher was then able to test for strength, power, and endurance, while charting maximal torque output throughout the entire range of motion.

Hunter et al. (1979) reported the purpose of isokinetic testing in preseason screening as:

> "1. To identify those players with possible knee pathology resulting in strength levels below those adequate to play.
>
> 2. To provide a permanent record of quadricep and hamstring strength in the event that rehabilitation of the knee was necessary at a later time."

The author indicated that isokinetic testing may not be an absolute predictor of injury, but it will reveal those who are likely to have problems in the future.

Gleim, Nicholas, and Webb (1978) introduced the cognitive term of "Total Leg Strength" (TLS) in respect to isokinetic testing. The TLS concept of testing includes five motions: knee flexion and extension, and hip flexion, abduction and adduction. Hip extension was excluded due to problems of stabilization and isolation of the desired musculature, which was a limitation of the equipment. The authors felt this total score offered a better interpretation of injury because imbalances would result in, "... a discontinuity of the biomechanical link system." TLS was felt to give a better indication of disorder than the relationship of single muscle groups. TLS could also be useful as a criteria for an athlete's return to competition as it enables the clinician a method of quantifying the dynamic strength of muscles through the full range of motion.

Clarkson et al. (1982) examined isokinetic strength and endurance to fiber type. Their study examined knee extensors after different pre-testing exercise bouts to determine the

changes in initial isokinetic torque and the characteristics of fatigue. The results indicated that the different pre-test exercise would effect the initial isokinetic strength, but the rate of fatigue remained consistent despite the initial strength. These results did not correlate well to muscle fiber type, but did correlate with body size and thigh circumference, indicating that body size was a better indicator of isokinetic strength.

Davies (1984) published his A Compendium of Isokinetics in Clinical Usage compiling the most thorough scan of isokinetics compared to other exercise, protocol for testing, identification of pathologies, and norms of various groups from previous testing. Davies described the advantages and disadvantages of isokinetic testing. The advantages were:

1. Efficiency - the only way to load a dynamically contracting muscle to its maximum capability at every point of the range of motion.

2. Safety - an individual will never meet more resistance than he can handle because the resistance is equal to the force applied.

3. Accommodating resistance - predicted on the change of the musculo-tendinous length tension ratio, the change in skeletal leverage, fatigue and pain.

Some of the disadvantages of isokinetic testing were:

1. The cost of the equipment is greater than other

forms of resistance exercise.

2. Isokinetic resistance does not eccentrically load the muscle.

3. The lack of personnel trained in the use and interpretation of the equipment and data.

Davies (1984) describes the parameters in which Cybex graphs may be interpreted as:

1. bilateral
2. unilateral ratio of respective agonist/antagonist
3. torques to body weight
4. comparison to normative data

Bilateral comparison involves comparing the involved limb with the uninvolved limb, or the dominate limb with the nondominate limb. Torque values that are greater than 10-15% difference between limbs would indicate that a pathology exists.

Unilateral ratios of agonist/antagonist can identify weakness between muscle groups. It should be noted that these relationships change at different velocities, thus stressing the need for full spectrum velocity testing.

Comparing torques to body weight gives the clinician another dimension of interpretation. Many times the patient may have equal bilateral torque and proper unilateral ratios. But if the torques are not equal to established norms for their body size, they may be susceptible to injury.

Comparison of scores to normative data is controversial, but used properly for specific populations they may serve as guidelines for both testing and rehabilitation.

Summary Testing of athletes in football has been going on for years. Isokinetic testing has given the researcher a tool which dynamically loads the muscle maximally at every point of the range of motion. Isokinetic testing is speed specific which allows testing of strength, power, and endurance, while producing a graph for permanent records.

Isokinetic Testing of College Football Players

Davies (1984) reported quadriceps and hamstring peak torques, and H/Q ratios of 200 college seniors at four speeds (45 degrees/second, 180 degrees/second, 240 degrees/second, and 300 degrees/second). The scores were reported by position to identify isokinetic characteristics of athletes by position. Peak torques at 45 degrees/second for the quadriceps ranged from 282 foot pounds at defensive tackle, to 211 foot pounds at receiver. The hamstrings at 45o/second had peak torques from 173 foot pounds at defensive tackle, to 120 foot pounds at receiver. At 180 degrees/second, the quadriceps ranged from 142 foot pounds at defensive end and tackle, to 104 foot pounds at receiver. The hamstrings at 180 degrees/second ranged from 100 foot pounds at linebacker, to 68 foot pounds at punter. At 300 degrees/second the

quadricep ranged from 88 foot pounds at defensive ends to 64 foot pounds at receiver. The hamstring at 300 degrees/second ranged from 72 foot pounds at offensive tackle, to 57 foot pounds at receiver. The data indicated that the torque of both the quadricep and hamstring decreased as the speed increased, because the muscle had less time for recruitment of muscle fiber. Also the relationship of size and absolute strength was demonstrated by the larger players having greater scores than the smaller players.

In the same study Davies reported the hamstring/ quadricep ratio (H/Q). At 45 degrees/second the H/Q ranged from a high of 66% for tight ends, to a low of 57% for both offensive tackles and receivers. At 180 degrees/second the H/Q ranged from a high of 83% for quarterbacks, to a low of 68% for defensive ends. Also at 300 degrees/second the high for the H/Q was 93%, again by the quarterbacks, to a low of 79% by the linebackers. These norms, though not all inclusive, do demonstrate some classic relationships. The first, and most important, was as the speed increased the ratio became closer to one, indicating that at the slower speeds measuring strength (45 degrees/second) the quadriceps were dominate. At the faster more functional speeds measuring power (180 and 300 degrees/second) the relationship between the quadriceps and the hamstrings became closer. This might suggest that the hamstrings, along with the

quadriceps, might lend a significant role for muscular stabilization of the knee at functional speeds. The second relationship indicated by these results was the difference between positions at the same speeds. These variations between positions might indicate isokinetic characteristics of specific positions.

Davies (1984) evaluated 113 college football players, for a total of 226 knees. The quadriceps and hamstrings were tested at speeds of 60 degrees/second and 240 degrees/second, and 240 degrees/second for power endurance testing. The results of the hamstring/quadricep ratio (H/Q), the quadricep/weight ratio (Q/W) and hamstring/weight ratio (H/W), and the power endurance test were reported. At 60 degrees/second the H/Q was 69%, with a high of 130%, to a low of 43%. The H/Q at 240 degrees/second was 77%, and ranged from a high of 155%, to a low of 55%. The Q/W and H/W at 60 degrees/second was 93% for the quadriceps, and 64% for the hamstrings. The Q/W ranged from 129% to 58%, the H/W ranged from 90% to 45%. At 240 degrees/second the Q/W was 53%, and the H/W was 40%. The Q/W ranged from 74% to 25%, and the H/W ranged from 55% to 23%. The average number of quadricep and hamstring repetitions for a 50% decrease in initial peak torque at 240 degrees/second was 48. The quadricep and hamstring repetitions ranged from a high of 86 to a low of 22. These results allowed for evaluation for both muscle

balance between opposing muscle groups, and evaluation of torque relative to the players body weight.

In another study Davies et al. (1982) evaluated 34 college seniors, or 68 knees using a Cybex II and a Digital Work Integrator (DWI). The DWI allowed for instantaneous analyzation of total work. The 50% decrease test was performed, and the DWI was used to indicate total work. The average number of repetitions resulting in a 50% decrease was 47.4 repetitions for the right leg, and 46.2 repetitions for the left leg. When analyzed by the DWI the average amount of total work was 2978.8 foot pounds for the right leg, and 2880.6 foot pounds for the left leg. The quadricep and hamstring repetitions ranged from a low of 34 to a high of 74.

Summary Previous testing of college football players help identify characteristics of different positions, the relationships between opposing muscle groups, and the relationship between torque output and body weight.

CHAPTER 3

Research Methodology and Data Analysis

The focus of this study was to determine if there was a significant difference in measures of peak isokinetic torque of knee flexor and extensor muscles in college football players subsequent to participation in spring football.

The Sources of Data

The sources of data for the study were based on the isokinetic measures of 53 returning University of the Pacific varsity football players who participated in and completed the 1986 spring football season. Of the 53 tested players, 29 played offensive positions and 24 played defensive positions. Also, of the 53 tested players, 30 played skill positions and 23 played line positions.

Data Collecting Instrument

The Cybex II Isokinetic Dynamometer coupled with a Cybex Dual Channel Recorder was utilized to quantify peak isokinetic torque of the quadriceps and hamstrings across speeds (60 degrees/second, 180 degrees/second, and 300 degrees/second). The machine was calibrated according to the procedure established by Lumex Corporation, makers of the Cybex II. Moffroid et al. (1969) used a test-retest procedure to establish a reliability coefficient of r = 0.995. The coefficient of validity was found to be r =

0.999.

The peak isokinetic torque was recorded on the 360 foot pounds torque scale, the damping was set at 3, the position angle scale used was 150 degrees, the paper speed was 25 mm/second at 60 degrees/second, and 5 mm/second at 180 degrees/second and 300 degrees/second.

Procedure for Data Collection

The testing for the study was made possible through the consent of the coaching staff with the stipulation that testing did not interfere with the conditioning, the practices, or meetings of the players. The pre-test began on March 18 through March 21, 1986, and resumed on April 1 through April 4, 1986, with spring break interrupting testing. The post-test began May 5 and ended May 10, 1986. The 30 days between the pre-test and the post-test was spent in spring football. Spring football is a unique season to college football where 20 practices are allowed over a 30 day period. Testing began at 7 A.M. and continued until 9 A.M. daily for two reasons: 1. this time was open for all players, and 2. at this time the players were fresh and not fatigued from the activities of daily living.

The starting leg for each subject was randomized at the time of the first testing by the side the Cybex was left by the previously tested player. Because of the time needed for instrument alignment, the number of players that were tested,

and the limitation of testing time, this procedure was the most efficient. For the post-testing, the starting leg for the pre-test was used.

The pre and post-test protocol and body stabilization were established by Cybex (1983). The hip was maintained at 105 degrees of flexion. Mawdsley and Croft (1982) studied the effects of submaximal contractions before isokinetic testing. Their conclusion was the warmup should include at least one voluntary maximal contraction, this gives the subject the learning effect of maximal isokinetic contraction and stabilized torque scores. The present study used five progressive warmup contractions at each speed, with the fifth warmup being a maximal contraction. It was felt that this procedure would stabilize the test scores.

Five repetitions were performed at each speed (60 degrees/second, 180 degrees/second, and 300 degrees/second). The amount of time of the individual bout varied with the speed being tested: at 60 degrees/second the five repetitions took approximately 20 seconds to complete, at 180 degrees/second the five repetitions took approximately 7 seconds to complete, and at 300 degrees/second the five repetitions took approximately 4 seconds to complete. A recovery time of one minute was allowed between testing bouts as recommended by Cybex Protocol (1983). Players then completed the warmup bout at each speed before testing. The

testing of each player for both legs took approximately 10 minutes.

Analysis of the Data

The Cybex Strip Chart produced by the Cybex Dual Channel Recorder was initially analyzed using the Cybex Data Card, Grid B which measured the 360 foot pound torque scale, and the 150 degree scale. A "Lotus 1-2-3" spread sheet program for personal computers was incorporated to determine the mean, standard deviation, maximum, minimum, and range for the pre-test, post-test, and the amount of change.

The data was analyzed for significance at the 0.05 level of significance using a two-tailed test. The analysis of the team, skill position players, the difference between the offensive and defensive positions, and the difference between the skill position players and the linemen, had sample sizes larger than 30 which required the use of the normal distribution curve producing z-scores. The critical value for rejection of the hypothesis was $c = z = -1.96$ and 1.96. The offensive positions, defensive positions, and linemen all had sample sizes of less than 30, so the Student t-test was utilized. The offensive positions had a sample size of 29, with 28 degrees of freedom, the critical level for rejection of the hypothesis was $c = t = -2.05$ and 2.05. The defensive positions had a sample size of 24, with 23 degrees of freedom, the critical value for rejection of the hypothesis

was c = t = -2.07 and 2.07. The linemen had a sample size of 23, with 22 degrees of freedom, the critical value for rejection of the hypothesis was c = t = -2.07 and 2.07.

CHAPTER 4

Results and Discussion

The main problem of the study was to determine if there was a significant difference in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds (60 degrees/second, 180 degrees/second and 300 degrees/second) of a college football team subsequent to participation in a spring football season.

The subproblems of the study examined the following relationships:

a. Knee flexors and extensors across speeds.
b. The hamstring/quadricep ratio across speeds.
c. The quadricep/weight ratio across speeds.
d. The fast quadricep/slow quadricep ratio (300/60 degrees/second).

The hypotheses for all problems were stated in the null form.

Results

An analysis of the data gave way to the following results:

Main Problem: Team The main problem of the study was to determine if there was a significant difference in peak isokinetic torque of knee flexor and extensor muscles across speeds of a college football team subsequent to participation in spring football. The results of the main problem are summarized in Tables 1 and Graph 1 (pages 28 and 29).

The quadriceps, or knee extensors, peak isokinetic torque demonstrated statistically significant decreases across speeds for both legs. The z-score required for statistical significance was +1.96 and -1.96. The results ranged from 2.83 for the left quadricep at 180 degrees/second to 5.56 for the right quadricep at 60 degrees/second.

The hamstrings, or knee flexors, peak isokinetic torque decreased across speeds. Two scores demonstrated statistically significant differences from pre to post-test, the right hamstrings at 180 degrees/second with a z-score of 2.65, and the left hamstring at 300 degrees/second with a z-score of 1.98.

The results of the main problem demonstrated that a college football team's peak isokinetic torque of the knee flexor and extensor muscles significantly decreased as a result of participation in spring football. The quadriceps significantly decreased across speeds from pre to post-test. The hamstrings demonstrated a decreasing drift across speeds, while producing two statistically significant z-scores. Due to these findings the null hypotheis for the main problem was rejected.

Subproblem 1: Offensive Positions. The first subproblem was to determine if a significant difference existed in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds of offensive college

TABLE 1

TEAM

QUADRICEPS AND HAMSTRINGS

	Pre-Test		Post-Test		Change		
	$\bar{X}$	STD	$\bar{X}$	STD	$\bar{X}$	STD	z-Score
RQ60	199	32	175	33	24	32	5.56*
LQ60	199	35	181	32	18	25	5.34*
RQ180	138	21	126	21	12	19	4.68*
LQ180	136	23	128	18	8	21	2.83*
RQ300	101	17	91	17	10	14	5.30*
LQ300	101	21	91	16	10	22	3.37*
RH60	130	22	126	26	3	24	.93
LH60	130	25	126	21	4	18	1.65
RH180	102	18	97	18	5	14	2.65*
LH180	100	18	98	18	2	15	.99
RH300	80	15	77	16	3	12	1.85
LH300	80	15	76	17	4	15	1.98*

The z-score required for significance by a two-tailed test at the .05 level of significance was c = z = -1.96 and +1.96. The torque scores were reported in foot pounds.

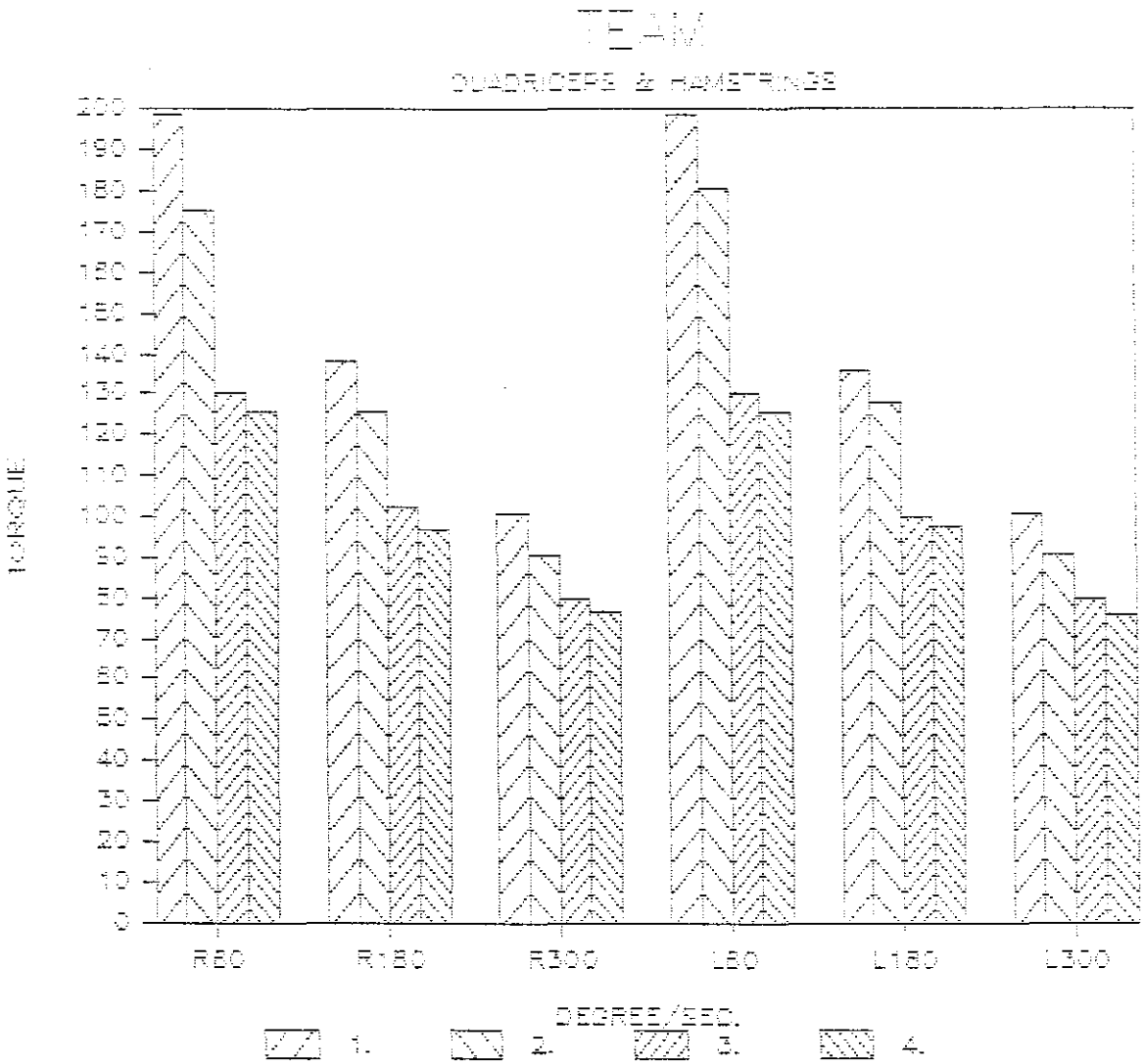
n = 53

* Denotes significance

Key: R - right L - left
Q - quadriceps H - hamstrings

Isokinetic speed are expressed in degrees/second

GRAPH 1



LEGEND

1. Pre-test quadriceps
2. Post-test quadriceps
3. Pre-test hamstrings
4. Post-test hamstrings

The torque scores were reported in foot pounds.

football players subsequent to participation in spring football. The results of subproblem one are summarized on Tables 2 and 3 (pages 31 and 33), and Graphs 2 and 3 (pages 32 and 34).

a. The quadriceps of the offensive positions demonstrated a decreasing drift in peak isokinetic torque across speeds, while producing four statistically significant differences from pre to post-test. The t-score required for statistical significance for the offensive positions was +2.05 and -2.05. The statistically significant t-scores ranged from 2.22 for the right quadricep at 180 degrees/second, to 3.85 for the left quadricep at 60 degrees/second.

The offensive positions hamstrings did not demonstrate a statistically significant difference in peak isokinetic torque from pre to post-test. Three t-scores were negative indicating an increase, and two t-scores were positive indicating a decrease. One t-score, the right hamstring at 300 degrees/second, had a t-score of zero which indicated there was no change from pre to post-test.

b. The offensive positions hamstring/quadricep ratio (H/Q) demonstrated an increasing drift across speeds for both legs, indicated by the negative t-scores. There were three statistically significant differences from pre to post-test, the right and left H/Q at 60 degrees/second with t-scores of

TABLE 2

OFFENSIVE POSITIONS

QUADRICEPS AND HAMSTRINGS

	Pre-Test		Post-Test		Change		
	$\bar{X}$	STD	$\bar{X}$	STD	$\bar{X}$	STD	z-Score
RQ60	187	28	169	29	18	32	3.03*
LQ60	189	32	174	28	15	21	3.85*
RQ180	132	18	125	18	7	17	2.22*
LQ180	129	21	125	16	5	20	1.35
RQ300	97	16	90	16	7	14	2.69*
LQ300	95	22	88	16	7	27	1.40
RH60	125	22	126	28	-1	26	-.21
LH60	124	27	125	21	-1	16	-.34
RH180	98	19	96	17	2	13	.83
LH180	95	17	98	17	-3	17	-.95
RH300	76	16	76	14	0	12	.00
LH300	75	15	74	15	1	15	.36

The t-score required for significance by a two-tailed student "t" test with 28 degrees of freedom at the .05 level of significance was c = t = -2.05 and +2.05. The torque scores were reported in foot pounds.

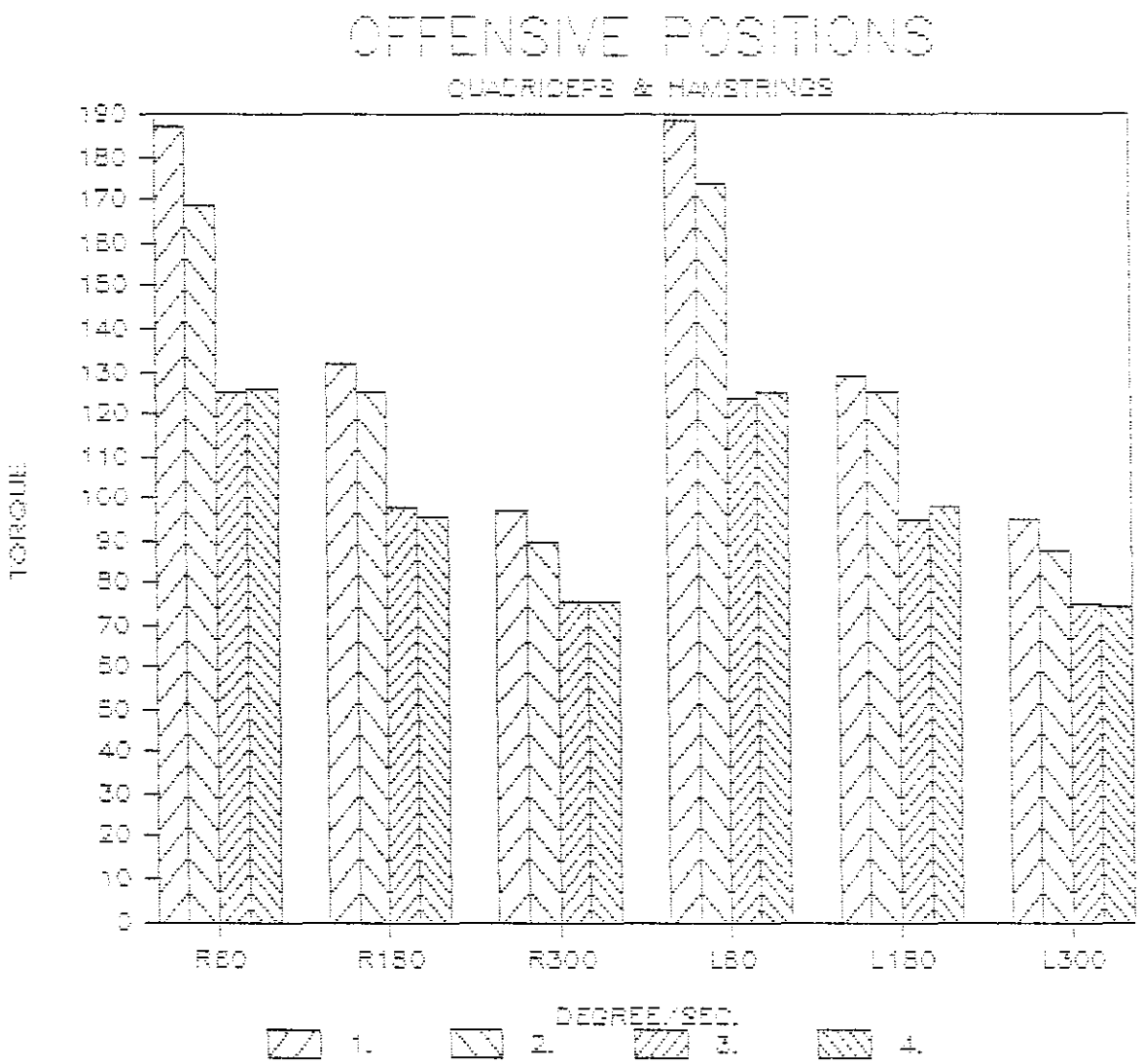
n = 29

* Denotes significance

Key: R - right L - left
Q - quadriceps H - hamstrings

Isokinetic speeds are expressed in degrees/second

GRAPH 2



LEGEND

1. Pre-test quadriceps
2. Post-test quadriceps
3. Pre-test hamstrings
4. Post-test hamstrings

The torque scores were reported in foot pounds.

TABLE 3

OFFENSIVE POSITIONS

HAMSTRING/QUADRICEP, QUADRICEP/WEIGHT

AND FAST QUADRICEP/SLOW QUADRICEP RATIOS

	Pre-Test		Post-Test		Change		
	$\bar{X}$	STD	$\bar{X}$	STD	$\bar{X}$	STD	t-Score
RH/Q60	68	13	76	15	-8	15	-2.87*
LH/Q60	67	14	72	12	-6	15	-2.15*
RH/Q180	74	10	77	12	-3	9	-1.80
LH/Q180	74	9	79	14	-5	14	-1.92
RH/Q300	78	12	85	11	-7	12	-3.14*
LH/Q300	80	12	85	13	-5	14	-1.92
RQ/W60	87	16	80	16	7	15	2.51*
LQ/W60	88	13	82	13	5	9	2.99*
RQ/W180	61	8	59	10	2	8	1.35
LQ/W180	60	11	59	10	1	9	.60
RQ/W300	45	6	42	7	3	6	2.69*
LQ/W300	44	8	42	7	2	11	.98
RFQ/SQ	52	7	54	10	-2	9	-1.19
LFQ/SQ	51	10	51	8	0	14	.00

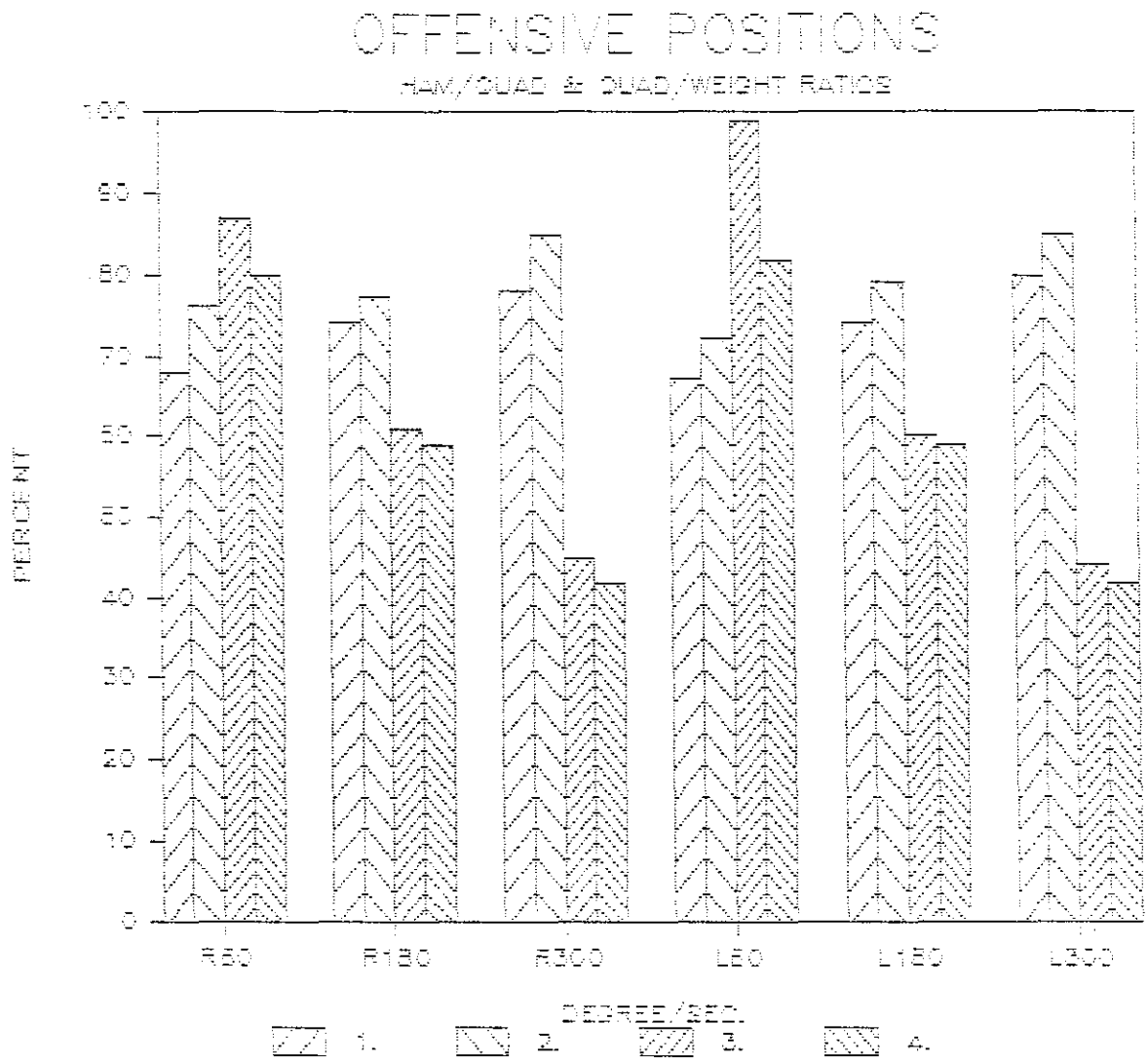
The t-score required for significance by a two-tailed student "t" test with 28 degrees of freedom at the .05 level of significance was c = t = -2.05 and +2.05. The scores were percent of foot pounds torque.

n = 29

* Denotes significance

Key: R - right L - left
H/Q - quadricep/hamstring ratio
Q/W - quadricep/weight ratio
FQ/SQ - fast quadricep/slow quadricep ratio
Isokinetic speeds are expressed in degrees/second

GRAPH 3



LEGEND

1. Pre-test H/Q
2. Post-test H/Q
3. Pre-test Q/W
4. Post-test Q/W

The scores were percent of foot pounds torque.

-2.87 and -2.15 respectively, and the right H/Q at 300 degrees/second with a t-score of 3.14.

c. The quadricep/weight ratio (Q/W) for the offensive positions demonstrated a decreasing drift across speeds, while producing three statistically significant differences from pre to post-test. The right and left Q/W at 60 degrees/second were statistically significant with t-scores of 2.51 and 2.99 respectively. The right Q/W at 300 degrees/second was statistically significant with a t-score of 2.69.

d. The fast quadricep/slow quadricep ratio (FQ/SQ) for the offensive positions did not demonstrate a statistically significant difference from pre to post-test.

The results of the first subproblem demonstrated the offensive positions peak isokinetic torque of the knee flexor and extensor muscles differed significantly as a result of participation in spring football. The decreasing drift of the quadriceps produced four significant z-scores. The H/Q and Q/W both demonstrated difference between the pre and post-test, with a combined six significant z-scores. Due to these findings the null hypothesis of the first subproblem was rejected.

Subproblem 2: Defensive Positions. The second subproblem was to determine if a significant difference existed in measures of peak isokinetic torque across speeds

subsequent to participation in spring football. The results of subproblem two are summarized in Tables 4 and 5 (pages 37 and 39), and Graphs 4 and 5 (pages 38 and 40).

a. The quadriceps of the defensive positions demonstrated statistically significant differences in peak isokinetic torque across speeds. The t-score required for statistical significance was +2.07 and -2.07. The results ranged from 2.80 for the left quadricep at 180 degrees/second to 5.28 for the right quadricep at 300 degrees/second.

The defensive positions hamstrings peak isokinetic torque decreased across speeds with five scores demonstrating statistical significance. The only exception was the right hamstring at 60 degrees/second with a t-score of 1.96. The statistically significant t-scores ranged from 2.61 for the right hamstring at 180 degrees/second to 3.56 for the left hamstring at 180 degrees/second.

b. The defensive positions H/Q demonstrated an increasing drift across speeds for both legs, indicated by the negative t-scores. There was one statistically significant difference from pre to post-test, the right H/Q at 60 degrees/second with a t-score of -3.92.

c. The defensive positions Q/W demonstrated statistically significant differences across speeds. The t-scores ranged from 2.94 for the left Q/W at 180 degrees/second to 5.72 for the right Q/W at 300

TABLE 4

DEFENSIVE POSITIONS

QUADRICEPS AND HAMSTRINGS

	Pre-Test		Post-Test		Change		
	$\bar{X}$	STD	$\bar{X}$	STD	$\bar{X}$	STD	t-Score
RQ60	213	29	182	36	33	31	5.22*
LQ60	211	34	189	35	24	29	4.05*
RQ180	146	21	127	24	20	19	5.16*
LQ180	143	23	132	20	12	21	2.80*
RQ300	105	16	92	17	14	13	5.28*
LQ300	107	18	94	15	14	14	4.90*
RH60	135	20	127	23	8	20	1.96
LH60	137	20	127	22	10	17	2.88*
RH180	107	16	98	19	8	15	2.61*
LH180	106	17	98	19	8	11	3.56*
RH300	84	12	78	17	7	11	3.12*
LH300	86	14	78	18	8	13	3.01*

The t-score required for significance by a two-tailed student "t" test with 22 degrees of freedom at the .05 level of significance was c = t = -2.07 and +2.07. The torque scores were reported in foot pounds.

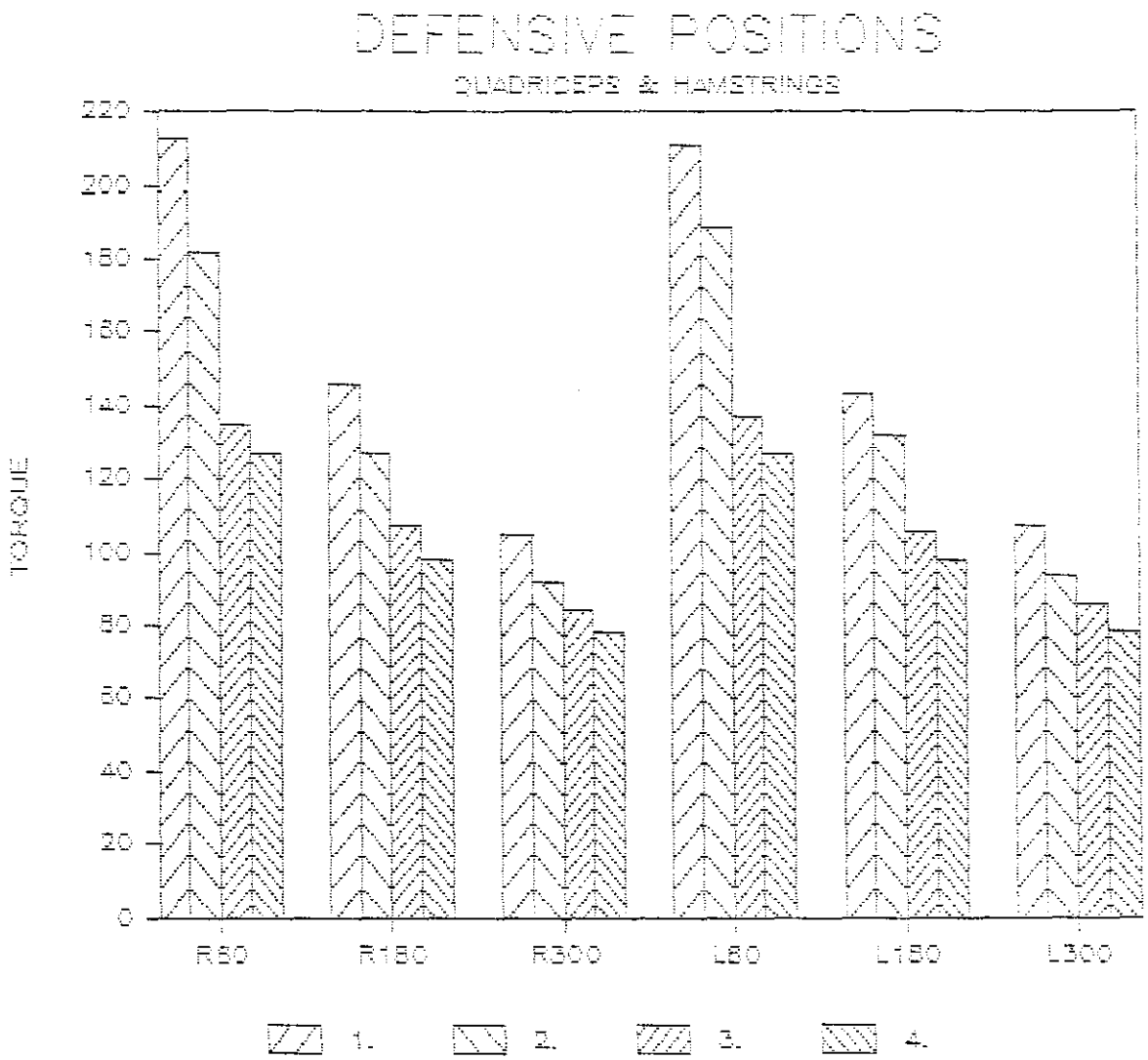
n = 24

* Denotes significance

Key: R - right L - left
Q - quadricep H - hamstring

Isokinetic speeds are expressed in degrees/second

GRAPH 4



LEGEND

1. Pre-test quadriceps
2. Post-test quadriceps
3. Pre-test hamstrings
4. Post-test hamstrings

The torque scores were reported in foot pounds.

TABLE 5

DEFENSIVE POSITIONS

HAMSTRING/QUADRICEP, QUADRICEP/WEIGHT

AND FAST QUADRICEP/SLOW QUADRICEP RATIOS

	Pre-Test		Post-Test		Change		
	$\bar{X}$	STD	$\bar{X}$	STD	X	STD	t-Score
RH/Q60	64	9	71	13	-8	15	-3.92*
LH/Q60	65	9	68	12	-4	10	-1.96
RH/Q180	73	9	79	17	-6	15	-1.96
LH/Q180	75	13	75	10	0	11	.00
RH/Q300	81	11	84	10	-3	12	-1.22
LH/Q300	81	12	83	14	-2	14	-0.70
RQ/W60	99	11	85	15	15	14	5.25*
LQ/W60	98	13	88	13	11	14	3.85*
RQ/W180	68	9	59	10	9	9	4.90*
LQ/W180	67	10	61	7	6	10	2.94*
RQ/W300	49	7	43	7	7	6	5.72*
LQ/W300	49	5	44	6	6	6	4.90*
RFQ/SQ	50	5	51	5	-2	5	-1.96
LFQ/SQ	51	7	50	8	0	6	.00

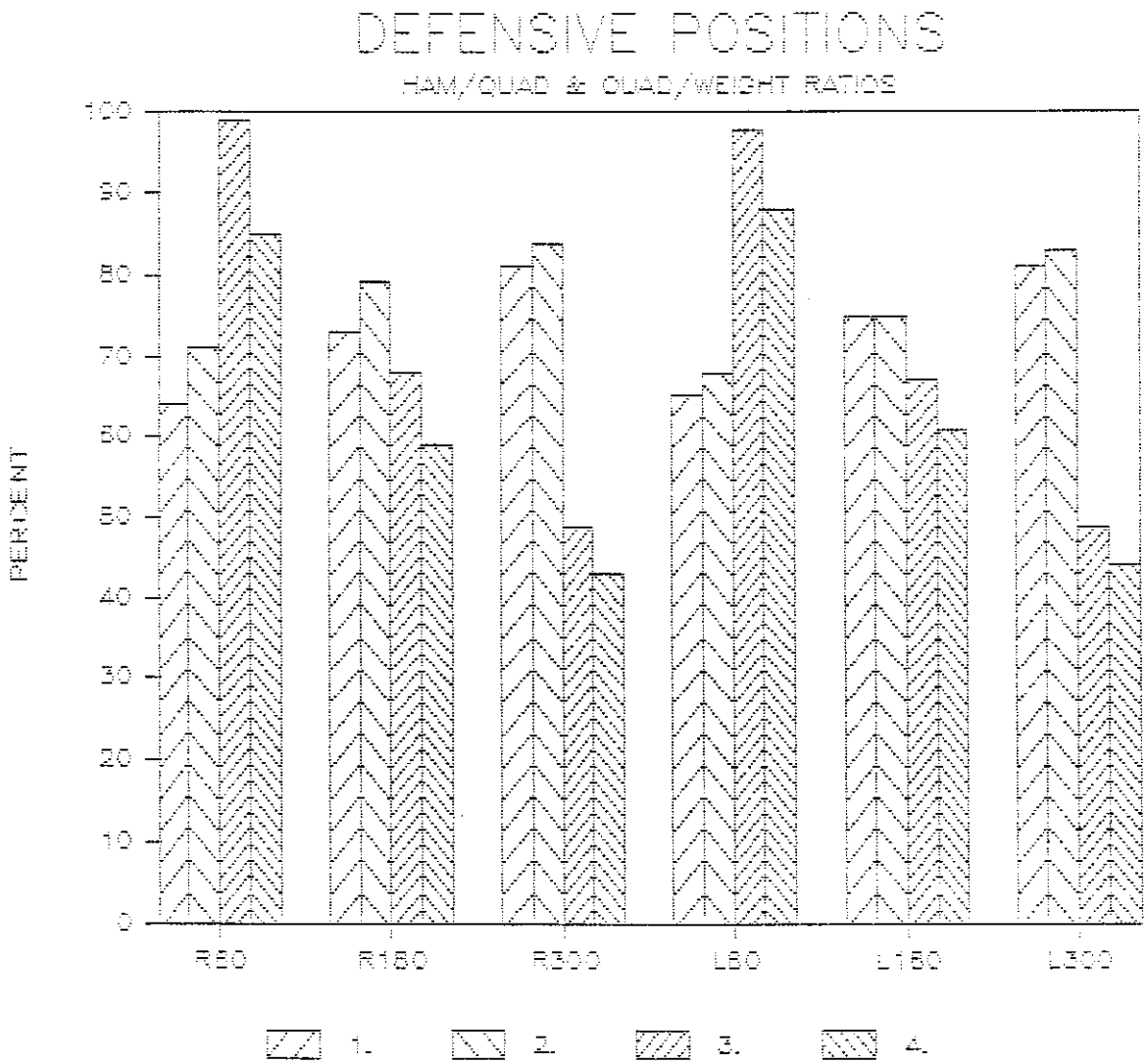
The t-score required for significance by a two-tailed student "t" test with 22 degrees of freedom at the .05 level of significance was c = t = -2.07 and +2.07. The scores were percent of foot pound torque.

n = 24

* Denotes significance

Key: R - right L - left
H/Q - hamstring/quadricep ratio
Q/W - quadricep/weight ratio
FQ/SQ - fast quadricep/slow quadricep ratio
Isokinetic speeds are expressed in degrees/second

GRAPH 5



LEGEND

1. Pre-test H/Q
2. Post-test H/Q
3. Pre-test Q/W
4. Post-test Q/W

The scores were percent of foot pounds torque.

degrees/second.

d. The defensive positions FQ/SQ did not demonstrate a statistically significant difference from pre to post-test.

The results of the second subproblem demonstrated the defensive positions peak isokinetic torque of the knee flexor and extensor muscles differed significantly subsequent to participation in spring football. The quadriceps and hamstrings both demonstrated significant z-scores across speeds indicating a decrease from pre to post-test. The Q/W decreased significantly across speeds from pre to post-test. Due to these finding the null hypothesis of the second subproblem was rejected.

Subproblem 3: Difference Between Offensive and Defensive Positions. The third subproblem was to determine if a significant difference existed in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds subsequent to participation in spring football. The results of subproblem three are summarized on Tables 6 and 7 (pages 42 and 43).

a. There was no statistically significant difference in peak isokinetic torque between the offensive and the defensive positions from pre to post-test. However, negative z-scores in the quadricep measures indicated the defensive positions experienced more change than the offensive positions in five of the six differences across speeds.

TABLE 6

DIFFERENCE BETWEEN OFFENSIVE AND DEFENSIVE POSITIONS

QUADRICEPS AND HAMSTRINGS

	Chg-Offense		Chg-Defense		Pooled Est.	
	$\bar{X}$	STD	$\bar{X}$	STD	STD	z-Score
RQ60	18	32	33	31	31.56	-1.72
LQ60	15	21	24	29	24.92	-1.30
RQ180	7	17	20	19	17.92	- .20
LQ180	5	20	12	21	20.45	-1.24
RQ300	7	14	14	13	13.56	-1.87
LQ300	7	27	14	14	22.11	-1.15
RH60	-1	26	8	20	23.49	-1.39
LH60	-1	16	10	17	16.41	-2.42*
RH180	2	13	8	15	14.93	-1.56
LH180	-3	17	8	11	14.59	-2.73*
RH300	0	12	7	11	11.58	-2.19*
LH300	1	15	8	13	14.14	-1.79

The z-score required for significance by a two-tailed test at the .05 level of significance was c = z = -1.96 and +1.96. The torque scores were reported in foot pounds.

n = 53

* Denotes significance

Key: R - right L - left
Q - quadriceps H - hamstring

Isokinetic speeds are expressed in degrees/second

TABLE 7

DIFFERENCE BETWEEN OFFENSIVE AND DEFENSIVE POSITIONS HAMSTRING/QUADRICEP, QUADRICEP/WEIGHT AND FAST QUADRICEP/SLOW QUADRICEP RATIOS

	Chg-Offense		Chg-Defense		Pooled Est.	
	$\bar{X}$	STD	$\bar{X}$	STD	STD	z-Score
RH/Q60	-8	15	-8	10	13.00	0.00
LH/Q60	-6	15	-4	10	13.00	- .56
RH/Q180	-3	9	-6	15	12.08	.90
LH/Q180	-5	14	0	11	12.73	-1.42
RH/Q300	-7	12	-3	12	12.00	-1.21
LH/Q300	-5	14	-2	14	14.00	- .78
RQ/W60	7	15	15	14	14.56	-1.99*
LQ/W60	5	9	11	14	11.53	-1.89
RQ/W180	2	8	9	9	8.49	-2.99*
LQ/W180	1	9	6	10	6.71	-2.70*
RQ/W300	3	6	7	6	6.00	-2.42*
LQ/W300	2	11	6	6	9.11	1.59
RFQ/SQ	-2	9	-2	5	7.48	0.00
LFQ/SQ	0	14	0	6	11.14	0.00

The z-score required for significance by a two-tailed test at the .05 level of significance was c = z = -1.96 and +1.96. The scores were percent of foot pounds torque.

n = 53

* Denotes significance

Key: R - right L - left
H/Q - hamstring/quadricep ratio
Q/W - quadricep/weight ratio
FQ/SQ - fast quadricep/slow quadricep ratio
Isokinetic speeds are expressed in degrees/second

The hamstring measures also indicated the defensive positions changed more than the offensive positions in peak isokinetic torque across speeds. The z-score required for statistical significance was +1.96 and -1.96. The three statistically significant differences were the left hamstring at 60 degrees/second with a z-score of -2.42, the left hamstring at 180 degrees/second with a z-score of -2.73, and the right hamstring at 300 degrees/second with a z-score of -2.19.

b. The difference between the offensive and the defensive positions H/Q did not produce a statistically significant difference. The right H/Q at 60 degrees/second did not change, and four of the five remaining measures indicated the defensive positions changed more than the offensive positions.

c. The difference between the offensive and the defensive positions Q/W demonstrated a negative drift, indicating the defensive positions changed more than the offensive positions. There were four statistically significant differences ranging from -1.99 for the right Q/W at 60 degrees/second to -2.99 for the right Q/W at 180 degrees/second.

d. The difference between the offensive and the defensive positions FQ/SQ did not produce a z-score, which indicated that both the offensive and defensive changed at

the same rate.

The results of the third subproblem demonstrated a significant difference between the offensive and defensive positions subsequent to participation in spring football. The quadriceps and hamstrings both demonstrated a negative drift, with three significant hamstring z-scores. The negative z-scores indicated the defensive positions changed more than the offensive positions. The Q/W also had negative z-scores across speeds, with four being significant. Due to these findings the null hypothesis of the third subproblem was rejected.

Subproblem 4: Skill Position Players. The fourth subproblem was to determine if a significant difference existed in measures of peak isokinetic torque of knee flexor and extensor muscles across speeds of skill position players subsequent to participation in spring football. The results of subproblem four are summarized on Tables 8 and 9 (pages 46 and 48), and Graphs 6 and 7 (pages 47 and 49).

a. The skill position players quadriceps demonstrated a decreasing drift in peak isokinetic torque across speeds, while producing five statistically significant differences from pre to post-test. The z-score required for statistical significance for the skill position players was +1.96 and -1.96. The statistically significant z-scores ranged from 2.39 for the left quadricep at 300 degrees/second to 4.30 for

TABLE 8

SKILL POSITION PLAYERS

QUADRICEPS AND HAMSTRINGS

	Pre-Test		Post-Test		Change		
	$\bar{X}$	STD	$\bar{X}$	STD	$\bar{X}$	STD	z-Score
RQ60	190	30	167	20	24	31	4.24*
LQ60	186	28	165	27	21	27	4.26*
RQ180	133	21	121	17	13	21	3.39*
LQ180	129	19	122	16	7	21	1.83
RQ300	97	17	86	15	11	14	4.30*
LQ300	93	75	85	16	7	16	2.39*
RH60	120	21	115	18	4	16	1.37
LH60	120	24	117	20	3	19	.86
RH180	96	19	91	16	5	14	1.95
LH180	94	17	92	16	1	19	.91
RH300	73	15	72	14	1	12	.45
LH300	75	15	70	16	3	15	1.46

The z-score required for significance by a two-tailed test at the .05 level of significance was c = z = -1.96 and +1.96. The torque scores were reported in foot pounds.

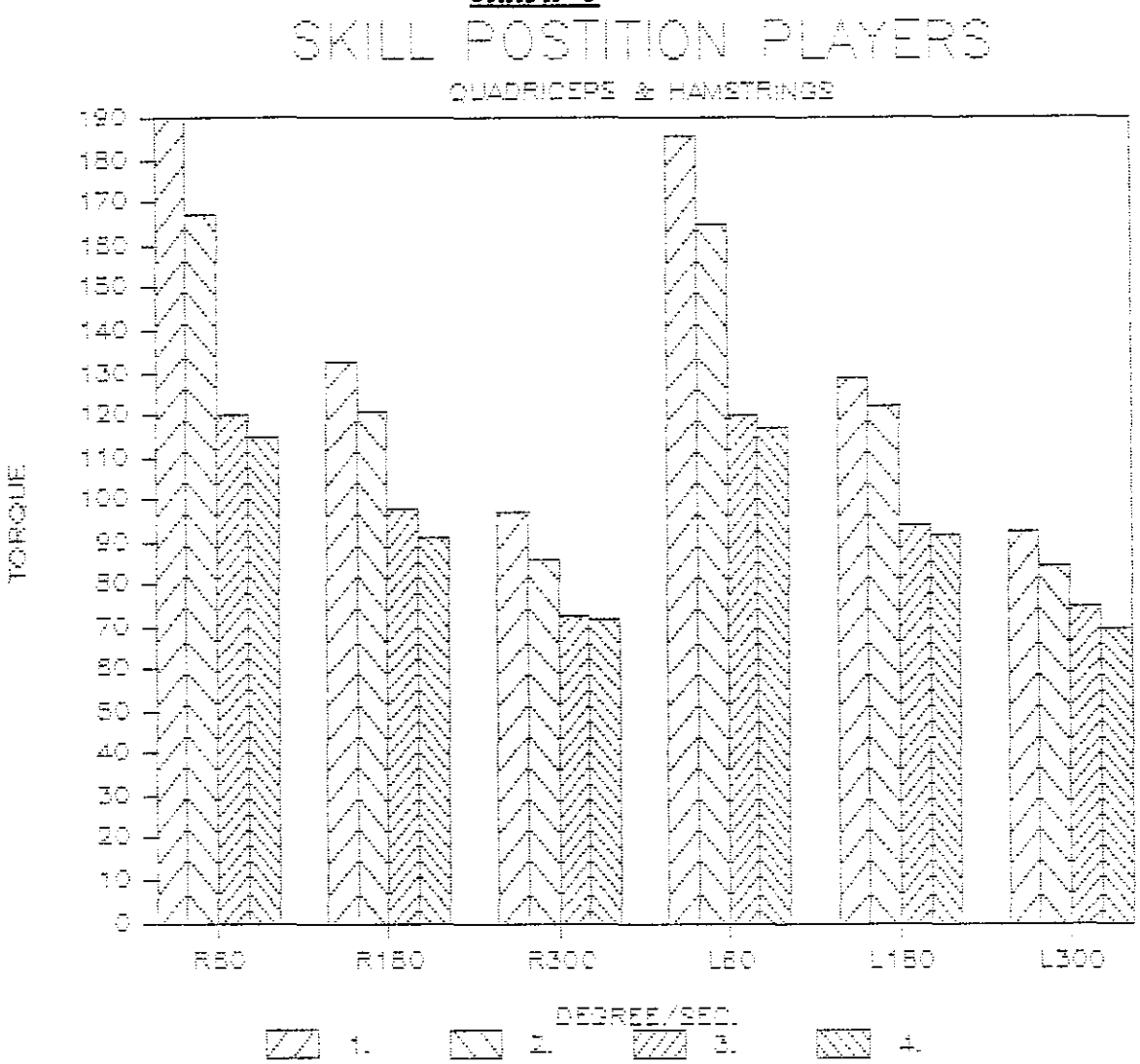
n = 30

* Denotes significance

Key: R - right L - left
Q - quadricep H - hamstring

Isokinetic speeds are expressed in degrees/second

GRAPH 6



LEGEND

1. Pre-test quadriceps
2. Post-test quadriceps
3. Pre-test hamstrings
4. Post-test hamstrings

The torque scores were reported in foot pounds.

TABLE 9

SKILL POSITION PLAYERS

HAMSTRING/QUADRICEP, QUADRICEP/WEIGHT

AND FAST QUADRICEP/SLOW QUADRICEP RATIOS

	Pre-Test		Post-Test		Change		
	$\bar{X}$	STD	$\bar{X}$	STD	$\bar{X}$	STD	z-Score
RH/Q60	63	9	70	13	-7	12	-3.20*
LH/Q60	65	12	72	13	-7	16	-2.40*
RH/Q180	72	9	76	14	-4	12	-1.83
LH/Q180	74	13	76	12	-2	12	.91
RH/Q300	76	12	84	10	-8	12	-3.65*
LH/Q300	81	11	83	16	-2	15	- .73
RQ/W60	97	14	86	14	11	14	4.02*
LQ/W60	94	12	85	13	9	13	3.79*
RQ/W180	67	9	62	8	6	10	3.29*
LQ/W180	65	10	62	8	3	11	1.49
RQ/W300	49	7	44	6	5	7	3.91*
LQ/W300	47	7	44	7	3	8	2.05*
RFQ/SQ	51	6	52	9	-1	8	- .68
LFQ/SQ	50	6	52	8	-2	8	-1.37

The z-score required for significance by a two-tailed test at the .05 level of significance was c = z = -1.96 and +1.96. The scores were percent of foot pound torque.

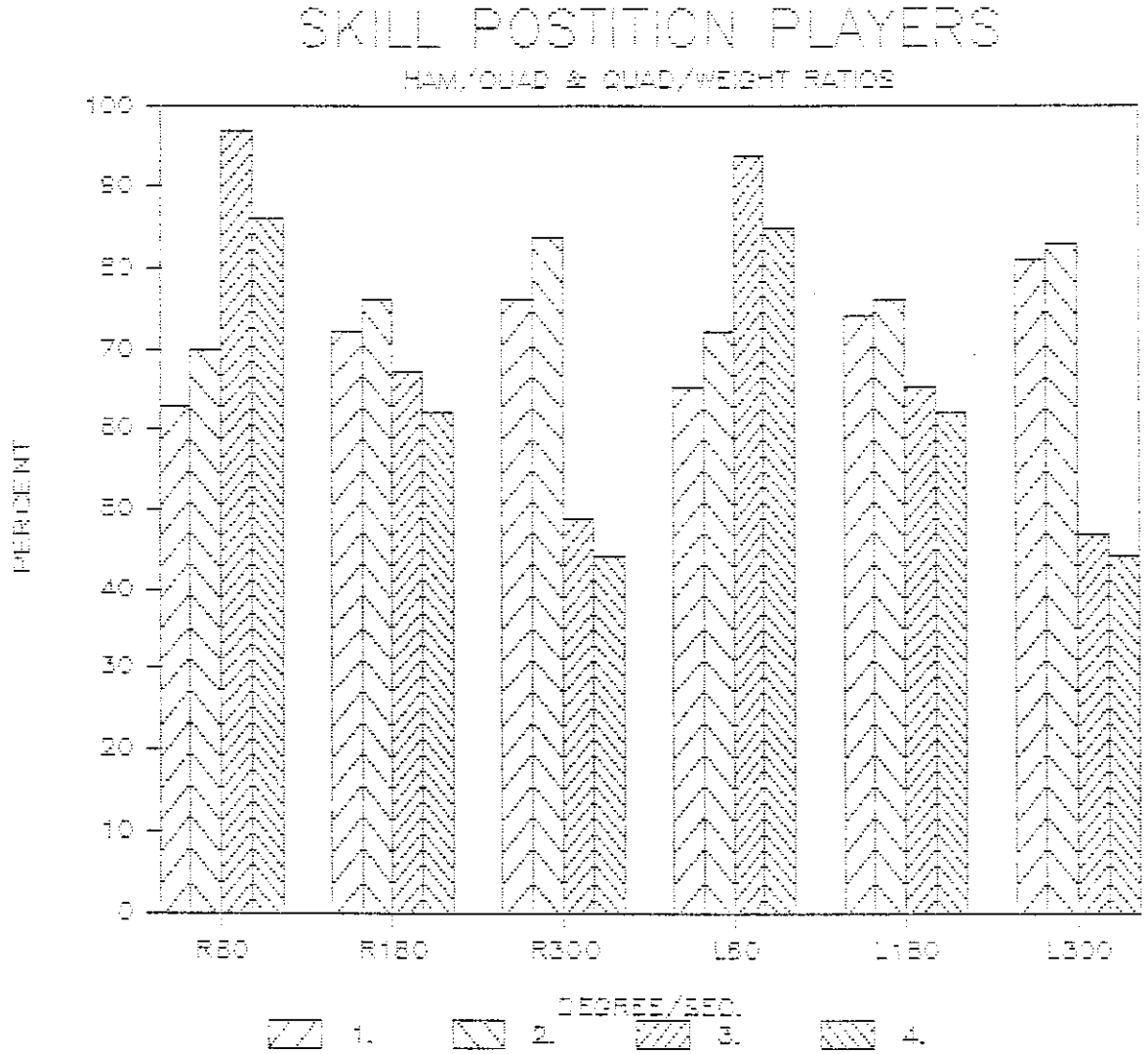
n = 30

* Denotes significance

Key: R - right L - left
Q - quadricep H - hamstring
Q/W - quadricep/weight ratio
FQ/SQ - fast quadricep/slow quadricep ratio

Isokinetic speeds are expressed in degrees/second

GRAPH 7



LEGEND

1. Pre-test H/Q
2. Post-test H/Q
3. Pre-test Q/W
4. Post-test Q/W

The scores were percent of foot pounds torque.

the right quadricep at 300 degrees/second.

The hamstrings of the skill position players demonstrated a decreasing drift, but did not produce a statistically significant difference from pre to post-test.

b. The skill position players H/Q demonstrated an increasing drift across speeds, with the exception of the left H/Q at 180 degrees/second which decreased. Three differences were statistically significant, both H/Q at 60 degrees/second with z-scores of -3.20 and -2.40 respectively, and the right H/Q at 300 degrees/second with a z-score of -3.65.

c. The skill position players Q/W demonstrated a decreasing drift across speeds with five of the six measures being statistically significant. The statistically significant differences ranged from 2.05 for the left Q/W at 300 degrees/second to 4.02 for the right Q/W at 60 degrees/second.

d. The skill position players FQ/SQ did not demonstrate a statistically significant difference from pre to post-test.

The results of the fourth subproblem demonstrated the skill position players measures of peak isokinetic torque of knee flexor and extensor muscles differed significantly subsequent to participation in spring football. The skill position players quadriceps and Q/W demonstrated statistically significant differences across speeds. The

hamstrings did not produce statistically significant differences, but did demonstrate a decreasing drift. The H/Q demonstrated statistically significant differences in half of the measures. Due to these findings the null hypothesis of the fourth subproblem was rejected.

Subproblem 5: Linemen. The fifth subproblem was to determine if a significant difference existed in measures of peak isokinetic torque of knee flexor of extensor muscles across speeds of linemen subsequent to participation in spring football. The results of subproblem five are summarized on Tables 10 and 11 (pages 52 and 54), and Graphs 8 and 9 (pages 53 and 55).

a. The linemens quadriceps demonstrated a decreasing drift in peak isokinetic torque across speeds. The t-score required for statistical significance for the linemen was +2.07 and -2.07. Five differences were statistically significant from pre to post-test, with t-scores ranging from 2.40 for the left quadricep at 300 degrees/second to 3.60 for the right quadricep at 300 degrees/second.

The linemens hamstrings also demonstrated a decreasing drift in peak isokinetic torque across speeds, producing one statistically significant difference, the right hamstring at 300 degrees/second with a t-score of 2.40.

b. The linemens H/Q demonstrated an increasing drift across speeds, with statistically significant differences

TABLE 10

LINEMEN

QUADRICEPS AND HAMSTRINGS

	Pre-Test		Post-Test		Change		
	$\bar{X}$	STD	$\bar{X}$	STD	$\bar{X}$	STD	t-Score
RQ60	210	29	186	37	25	34	3.53*
LQ60	218	34	204	24	14	21	3.20*
RQ180	146	18	133	24	12	16	3.60*
LQ180	145	25	137	17	8	20	1.92
RQ300	106	15	98	16	9	12	3.60*
LQ300	112	22	98	13	14	28	2.40*
RH60	143	15	142	28	2	32	.30
LH60	144	18	138	17	5	16	1.50
RH180	111	12	106	17	5	15	1.60
LH180	108	17	106	16	1	19	.25
RH300	89	10	83	15	6	12	2.40*
LH300	87	13	83	15	3	15	.96

The t-score required for significance by a two-tailed student "t" test with 22 degrees of freedom at the .05 level of significance was c = t = -2.07 and +2.07. The torque scores were reported in foot pounds.

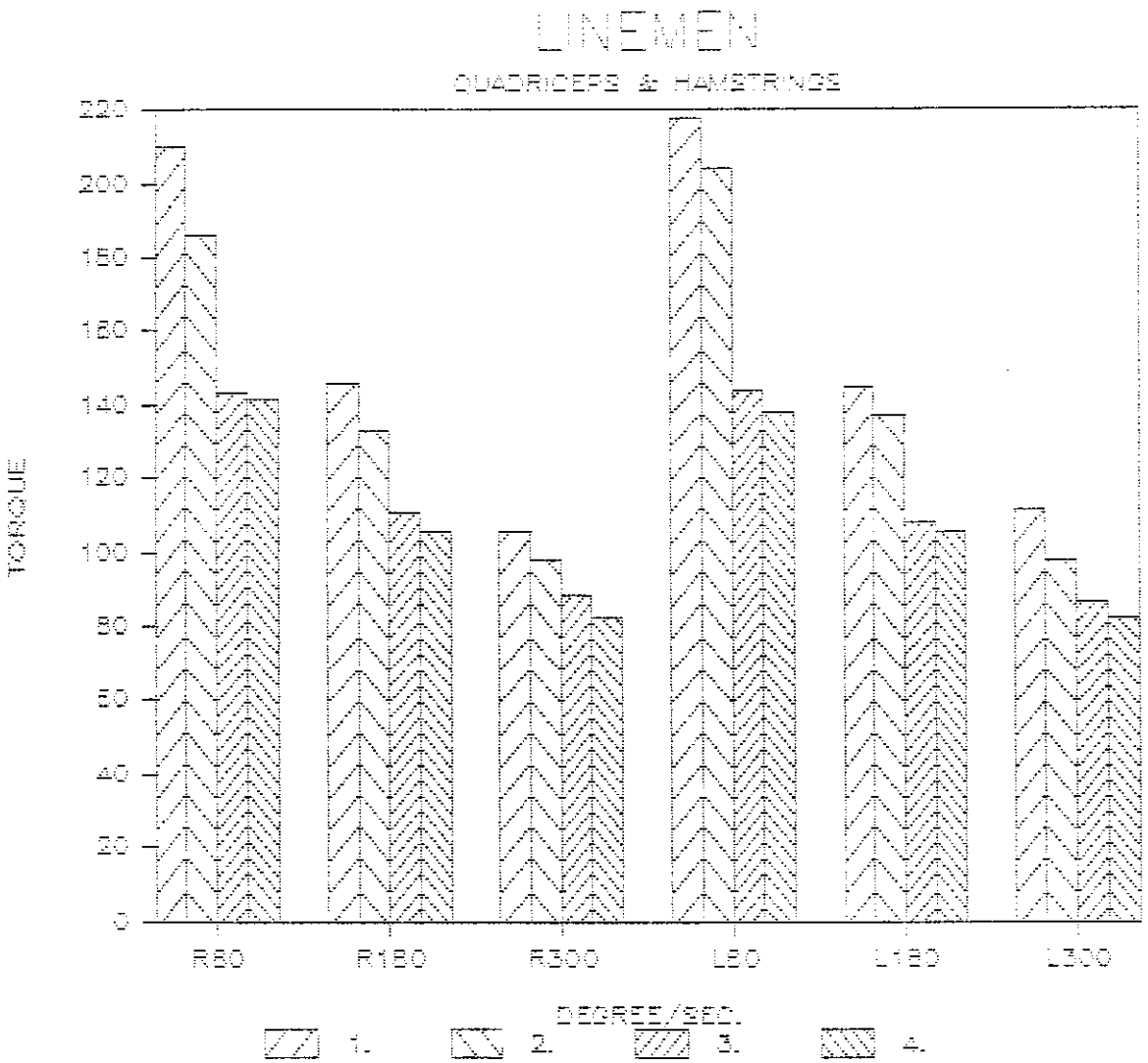
n = 23

* Denotes significance

Key: R - right L - left
Q - quadricep H - hamstring

Isokinetic speeds are expressed in degrees/second

GRAPH 8



LEGEND

1. Pre-test quadriceps
2. Post-test quadriceps
3. Pre-test hamstrings
4. Post-test hamstrings

The torque scores were reported in foot pounds.

TABLE 11

LINEMEN

HAMSTRING/QUADRICEP, QUADRICEP/WEIGHT

AND FAST QUADRICEP/SLOW QUADRICEP RATIOS

	Pre-Test		Post-Test		Change		
	$\bar{X}$	STD	$\bar{X}$	STD	$\bar{X}$	STD	t-Score
RH/Q60	69	13	78	18	-9	13	-3.32*
LH/Q60	67	12	69	11	-1	7	- .69
RH/Q180	77	9	81	15	-4	12	-1.60
LH/Q180	75	7	78	14	-4	15	-1.28
RH/Q300	84	10	85	12	-1	11	- .44
LH/Q300	79	13	85	10	-6	12	-2.40*
RQ/W60	87	14	77	17	9	14	3.08*
LQ/W60	90	17	85	14	5	9	2.66*
RQ/W180	60	8	55	10	4	7	2.47*
LQ/W180	60	11	57	9	3	9	1.31
RQ/W300	44	6	41	7	3	5	2.88*
LQ/W300	46	8	41	6	5	7	2.18*
RFQ/SQ	51	7	54	8	-3	7	-2.06
LFQ/SQ	52	12	48	6	4	14	1.37

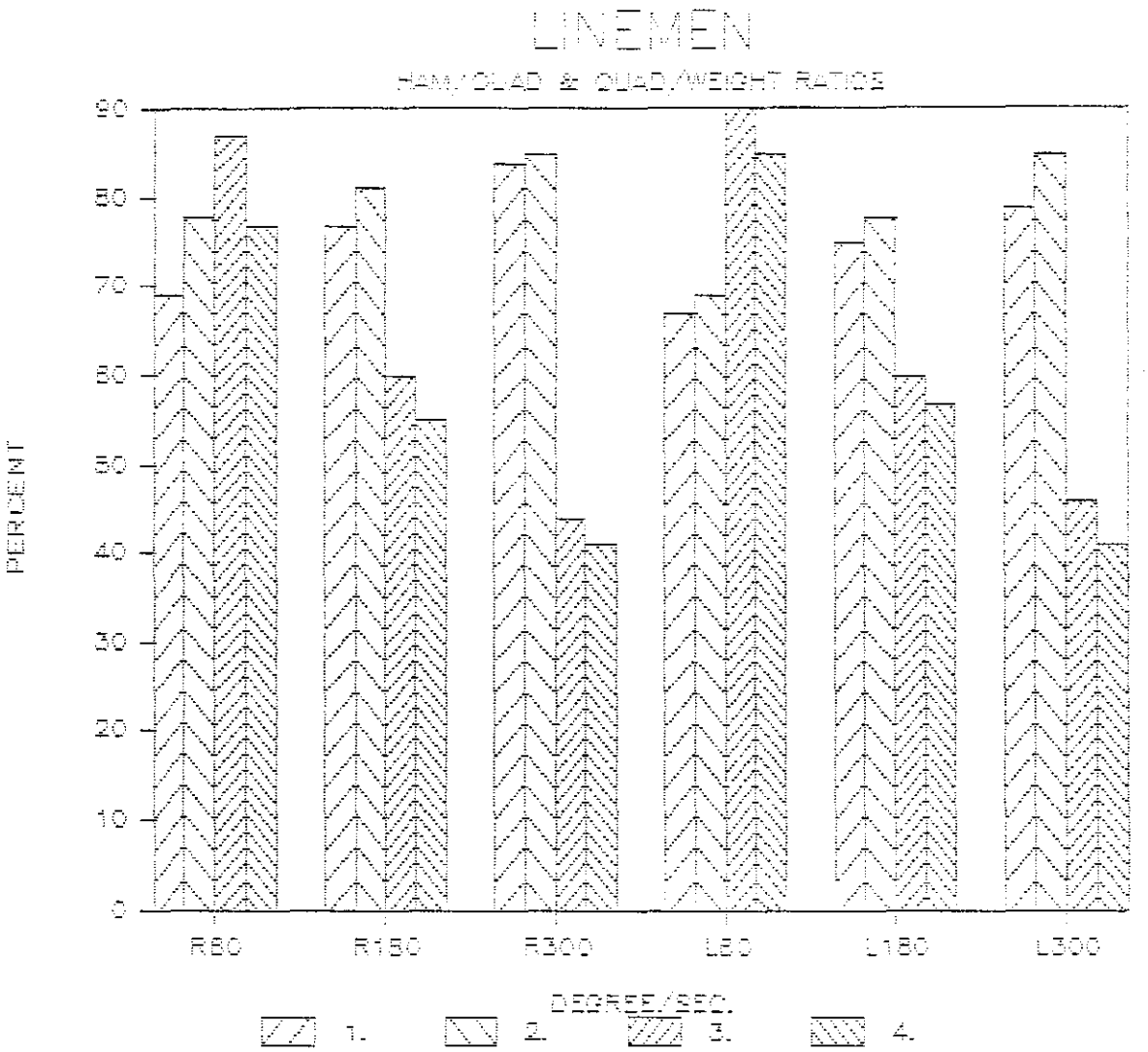
The t-score required for significance by a two-tailed student "t" test with 22 degrees of freedom at the .05 level of significance was c = t = -2.07 and +2.07. The scores were percent of foot pounds torque.

n = 23

* Denotes significance

Key: R - right L - left
Q - quadricep H - hamstring
Q/W - quadricep/weight ratio
FQ/SQ - fast quadricep/slow quadricep ratio
Isokinetic speeds are expressed in degrees/second

GRAPH 9



LEGEND

1. Pre-test H/Q
2. Post-test H/Q
3. Pre-test Q/W
4. Post-test Q/W

The scores were percent of foot pounds torque.

for the right H/Q at 60 degrees/second and the left H/Q at 300 degrees/second, having t-scores of -3.32 and -2.40 respectively.

c. The linemens Q/W demonstrated a decreasing drift across speeds, producing five statistically significant differences. The statistically significant differences ranged from 2.18 for the left Q/W at 300 degrees/second to 3.08 for the right Q/W at 60 degrees/second.

d. The linemens FQ/SQ did not produce a statistically significant difference from pre to post-test. However, the right FQ/SQ ratio did increase more than any similar measure in the study, producing a z-score of -2.06, where the critical value for significance was -2.07.

The results of the fifth subproblem demonstrated the linemens measures of peak isokinetic torque of knee flexor and extensor muscles differed significantly subsequent to participation in spring football. The linemens quadriceps and Q/W demonstrated statistically significant differences across speeds. The linemens hamstrings and H/Q demonstrated a decreasing drift across speeds with one and two differences having statistical significance respectively. Due to these findings the null hypothesis of the fifth subproblem was rejected.

Subproblem 6: Difference Between Skill Position Players and Linemen. The sixth subproblem was to determine if a

significant difference existed in measures of peak isokinetic torque of knee flexor and extensor muscles between skill position players and linemen subsequent to participation in spring football. The results of subproblem six are summarized on Tables 12 and 13 (pages 58 and 59).

a. There was no statistically significant difference in the quadriceps peak isokinetic torque across speeds between skill position players and linemen. There were three negative and three positive z-scores, indicating that neither group demonstrated a dominance in change.

The hamstrings also did not demonstrate a statistically significant difference between the two groups. There were three negative and two positive z-scores, and the right hamstring at 180 degrees/second had a z-score of 0.00.

b. The H/Q for the difference between skill position players and linemen demonstrated the only statistically significant difference of the sixth subproblem. The z-score required for statistical significance was +1.96 and -1.96. The right H/Q at 300 degrees/second, with a z-score of -2.18, indicated the linemen changed more than the skill position players.

c. There was no statistically significant difference between the Q/W of the skill position players and the linemen. Four of the six measures of Q/W had positive z-scores, one had a negative z-score, and one had a z-score

TABLE 12

DIFFERENCE BETWEEN SKILL POSITION PLAYERS AND LINEMEN

QUADRICEPS AND HAMSTRINGS

	Chg - SPP		Chg-Linemen		Pooled Est.	
	$\bar{X}$	STD	$\bar{X}$	STD	STD	z-Score
RQ60	24	31	25	34	32.33	- .11
LQ60	21	27	14	21	24.60	1.03
RQ180	13	21	12	16	19.00	.19
LQ180	7	21	8	20	20.75	- .18
RQ300	11	14	9	12	13.19	.55
LQ300	7	16	14	28	22.00	-1.15
RH60	4	16	2	32	24.23	- .30
LH60	3	19	5	16	17.78	- .40
RH180	5	14	5	15	14.46	.00
LH180	2	12	1	19	15.43	.23
RH300	1	12	6	12	12.00	-1.50
LH300	4	15	3	15	15.00	.24

The z-score required for significance by a two-tailed test at the .05 level of significance was c = z = -1.96 and +1.96. The torque scores were reported in foot pounds.

n = 53

* Denotes significance

Key: R - right L - left
Q - quadricep H - hamstring

Isokinetic speeds are expressed in degrees/second

TABLE 13

DIFFERENCE BETWEEN SKILL POSITION PLAYERS AND LINEMEN HAMSTRING/QUADRICEP, QUADRICEP/WEIGHT AND FAST QUADRICEP/SLOW QUADRICEP RATIOS

	Chg - SPP		Chg-Linemen		Pooled Est.	
	$\bar{X}$	STD	$\bar{X}$	STD	STD	z-Score
RH/Q60	-7	12	-9	13	12.45	.58
LH/Q60	-7	16	-1	7	12.29	-1.68
RH/Q180	-4	12	-4	12	12.00	.00
LH/Q180	-2	12	-4	15	13.38	.54
RH/Q300	-8	12	-1	11	11.58	-2.18*
LH/Q300	-2	15	-6	12	13.78	1.04
RQ/W60	11	14	9	14	14.56	.50
LQ/W60	9	13	5	9	11.45	1.26
RQ/W180	6	10	4	7	8.83	.82
LQ/W180	3	11	3	9	10.20	.00
RQ/W300	5	7	3	5	6.24	1.16
LQ/W300	3	8	5	11	9.43	- .76
RFQ/SQ	-1	8	-3	7	7.62	.94
LFQ/SQ	-2	8	4	14	11.00	.65

The z-score required for significance by a two-tailed test at the .05 level of significance was c = z = -1.96 and +1.96. The scores were percent of foot pounds torque.

n = 53

* Denotes significance

Key: R - right L - left
Q - quadricep H - hamstring
Q/W - quadricep/weight ratio
FQ/SQ - fast quadricep/slow quadricep ratio

Isokinetic speeds are expressed in degrees/second

of zero.

d. The FQ/SQ did not produce a statistically significant difference between the skill position players and the linemen.

The results of the sixth subproblem demonstrated only one significant difference in measures of peak isokinetic torque across speeds between skill position players and linemen. The H/Q demonstrated the only significant z-score of the sixth subproblem, indicating the linemen demonstrated the significant difference. Neither the skill position players nor the linemen demonstrated a dominate drift in the measures of peak isokinetic torque. Due to this finding the null hypothesis of the sixth subproblem was rejected.

Discussion

The results of the study lead to the following points of discussion:

1. The statistically significant decrease of the team's quadricep peak isokinetic torque across speeds for both legs is the most important find of the study. The quadriceps offer the major muscular stability of the knee. It is altogether reasonable to assert that a significant decrease in quadricep strength and power increases the probability of knee trauma and injury.

During the pre-season, the team's weight training and plyometric program were designed to increase strength and

power. During spring football there was a decrease in both the quadricep and hamstring peak isokinetic torque. The decrease might be a result of the shift from the specific strength training to the skill activities of spring football practices. The change in activity might not have had the intensity to maintain or increase peak isokinetic torque.

2. The defensive positions changed more than any other group of the study. Of the 26 measures tested, 18 demonstrated statistical significance from pre to post-test. When compared to the offense, the defense changed more in 21 of the 26 measures, seven of which were statistically significant. It should be noted that the pre-test scores of quadriceps and hamstrings were higher for the defensive positions than the offensive positions. In the post-test, even though the defensive positions decreased more than the offensive positions, the defensive positions still maintained higher scores. The defensive positions advantage over the offensive positions in peak isokinetic torque is similar to Davies (1984) results in his testing of college football players. This might reflect desirable characteristics of the defensive players.

3. The skill position players and the linemen offer a comparison of two distinctly different groups. The skill position players by nature are smaller and quicker, while linemen are larger and stronger. The mean peak isokinetic

torque of the two groups bear out this relationship. The linemen had higher absolute torque production in the quadricep and hamstring across speeds. When the relative measures were examined, ie, the H/Q and Q/W ratio, the skill position players had the higher values. This relative difference between the two groups might explain the speed and quickness advantage of the skill position players.

The sixth subproblem compared the difference between the skill position players and the linemen. There was only one statistically significant difference, the right H/Q ratio at 300 degrees/second. Also, there was not a consistent drift by either group. This is important because it indicates that players changed at the same rate. Coaches could benefit from this knowledge. Even though players at different positions practice different skills, the rate of change is consistent for the entire team.

4. The graphs and tables of the study indicate two relationships:

1) The quadricep mean peak isokinetic torque was greater than the hamstrings across speeds. As the speeds of contractions increased two observations can be made: (a) The torque production decreased. As the speed of the contraction increased, the muscle had less time for muscle fiber recruitment. (b) The difference between the two opposing muscle groups decreased with the increased speed. The

fastest speed tested (300 degrees/second) provided the best approximation of functional speed. Disparities between quadricep and hamstring torque diminish as speed increases. This suggests that quadricep superiority may reflect traditional testing modes, not functional speed.

2. The H/Q and the Q/W demonstrated an inverse relationship. The H/Q was lower at the slower speed (60 degrees/second) and increased with increasing speed. The Q/W had its highest values at the slow speed and decreased as the speed increased. These two relationships have been reported by other studies. They are consistent with the nature of isokinetic resistance, which is speed specific accommodating resistance.

CHAPTER 5

Summary, Conclusions and Recommendations

Summary

Fifty-three University of the Pacific varsity football players were tested for peak isokinetic torque of the knee flexor and extensor muscles prior to and after the spring football season. The study examined if a college football team's peak isokinetic torque significantly changed over spring football. The instrument for data collection was a Cybex II, coupled with a Cybex Dual Channel Recorder. The data was analyzed at the 0.05 level of significance using a two-tailed test. The players were tested both prior to and after spring football at three speeds (60 degrees/second, 180 degrees/second, and 300 degrees/second).

The main problem of the study was to determine if there was a significant difference in peak isokinetic torque of knee flexor and extensor muscles across speeds (60 degrees/second, 180 degrees/second, and 300 degrees/second) of a college football team subsequent to participation during a spring football season.

The following subproblems were examined in the study:

1. To determine if a significant difference existed in measures of peak isokinetic torque across speeds of knee flexor and extensor muscles of offensive college football

players subsequent to participation in spring football.

2. To determine if a significant difference existed in measures of peak isokinetic torque across speeds of knee flexor and extensor muscles of defensive college football players subsequent to participation in spring football.

3. To determine if a significant difference existed in measures of peak isokinetic torque across speeds of knee flexor and extensor muscles between offensive and defensive college football players subsequent to participation in spring football.

4. To determine if a significant difference existed in measures of peak isokinetic torque across speeds of knee flexor and extensor muscles of skill position college football players subsequent to participation in spring football.

5. To determine if a significant difference existed in measures of peak isokinetic torque across speeds of knee flexor and extensor muscles of linemen college football players subsequent to participation in spring football.

6. To determine if a significant difference existed in measures of peak isokinetic torque of knee flexor and extensor muscles between skill position players and linemen college football players subsequent to participation in spring football.

The subproblems examined the following relationships:

a. Knee flexors and extensors across speeds.
b. The hamstring/quadricep ratio (H/Q) across speeds.
c. The quadricep/weight ratio (Q/W) across speeds.
d. The fast quadricep/slow quadricep ratio (FQ/SQ = 300/60 degrees/second).

The results indicated that the decrease in the team's quadricep torque was statistically significant across speeds for both legs. The hamstring torque decreased in two measures of power.

The offensive positions also experienced a decrease in quadricep torque across speeds, with four measures demonstrating statistical significance. The offensive positions hamstring/quadricep ratio (H/Q) demonstrated an increase across speeds, with three statistically significant measures. The offensive positions quadricep/weight ratio (Q/W) demonstrated a decrease across speeds, with three statistically significant measures.

The defensive positions demonstrated statistically significant decreases of the quadricep torque across speeds. Hamstring torque also decreased across speeds, with five measures demonstrating statistical significance. The defensive positions H/Q ratio demonstrated only one statistically significant increase. The defensive positions Q/W ratio was statistically significant across speeds.

The difference between the offensive and defensive positions demonstrated no statistical significance in the quadricep torque, but the defensive positions demonstrated a

greater magnitude of change across speeds. The defensive positions hamstrings changed more than the offensive positions across speeds, with three measures demonstrating statistical significance. The defensive positions demonstrated more change than the offensive positions in the Q/W across speeds, with four measures statistically significant. The defensive positions demonstrated statistical significance in four measures of the Q/W ratio.

The skill position players decreased in quadricep torque across speeds, with five measures demonstrating statistically significant change. The H/Q ratio demonstrated three statistically significant decreases. The skill position players Q/W ratio demonstrated five statistically significant decreases.

The linemens quadriceps decreased across speeds, with five measures demonstrating statistical significance. Linemen hamstring torque decreased across speeds, with only one statistically significant measure. Linemen H/Q ratio increased across speeds, with two measures demonstrating statistically significant measures. Linemen Q/W ratio decreased across speeds, with five measures demonstrating statistical significance.

The comparison of the change in skill position players versus the change in linemen only demonstrated one statistically significant measure, the right H/Q at 300

degrees/second.

Conclusions

The results of the study support the following conclusions:

1. The peak isokinetic torque of knee flexor and extensor muscles of a college football team could expect the following changes subsequent to participation in spring football: (a) A decrease in knee extensor muscles, or quadriceps, peak isokinetic torque across speeds. (b) A decrease in knee flexor muscles, or hamstrings, peak isokinetic torque.

2. Measures of peak isokinetic torque of knee flexor and extensor muscles of offensive positions on a college football team could expect the following changes subsequent to participation in spring football: (a) A decrease in knee extensor muscles, or quadriceps, peak isokinetic torque. (b) An increase in the hamstring/quadricep ratio (H/Q). (c) A decrease in the quadricep/weight ratio (Q/W).

3. Measures of peak isokinetic torque of knee flexor and extensor muscles of defensive positions on a college football team could expect the following changes subsequent to participation in spring football: (a) A decrease in knee extensor muscles, or quadriceps, peak isokinetic torque across speeds. (b) A decrease in knee flexor muscles, or hamstrings, peak isokinetic torque. (c) An increase in the

hamstring/quadricep ratio (H/Q). (d) A decrease in the quadricep/weight ratio (Q/W) across speeds.

4. Differences in measures of peak isokinetic torque of knee flexor and extensor muscles between offensive and defensive positions on a college football team could expect the following changes subsequent to participation in spring football: (a) The defensive positions knee flexors, or hamstrings, could decrease more than the offensive positions in peak isokinetic torque. (b) The defensive positions quadricep/weight ratio (Q/W) could decrease more than the offensive positions.

5. Measures of peak isokinetic torque of knee flexor and extensor muscles of skill position players on a college football team could expect the following changes subsequent to participation in spring football: (a) A decrease in knee extensors, or quadriceps, in peak isokinetic torque. (b) An increase in the hamstring/quadricep ratio (H/Q). (c) A decrease in quadricep/weight ratio (Q/W).

6. Measures of peak isokinetic torque of knee flexor and extensor muscles of linemen on a college football team could expect the following changes subsequent to participation in spring football: (a) A decrease in knee extensors, or quadriceps, in peak isokinetic torque. (b) A decrease in knee flexors, or hamstrings, in peak isokinetic torque. (c) An increase in the hamstring/quadricep ratio

(H/Q). (d) A decrease in the quadricep/weight ratio (Q/W).

7. Differences in measures of peak isokinetic torque of knee flexor and extensor muscles between skill position players and linemen on a college football team could expect the following changes subsequent to participation in spring football: (a) The linemen could increase more than the skill position players in a measure of hamstring/weight ratio (H/Q). The lack of substantial dominance by either group would indicate that the two groups change at the same rate.

Recommendations

The following recommendations for further study are suggested:

1. Repeat this study over a fall football season to determine if similar results would occur.

2. Repeat this study on other groups of football players, i.e. high school, junior college, other college teams, professional teams, to determine if the changes observed in the present study are similar at other levels of football.

3. An incidence of knee injury and measures of peak isokinetic torque should be compared to see if a relationship exists which might make players more susceptible to knee injuries.

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