THE EFFECT OF PROTECTIVE KNEE BRACES ON AGILITY AND MUSCLE PERFORMANCE

by

Michael A. Polascik

Thesis submitted to the faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements

for the degree of

MASTERS OF SCIENCE IN EDUCATION

in

Health and Physical Education

APPROVED:

Don R. Sebolt, Chairman

Janet L. Walberg

H. Duane Lagan

May, 1989

Blacksburg, Virginia

THE EFFECT OF PROTECTIVE KNEE BRACES ON AGILITY AND MUSCLE PERFORMANCE

by

Michael Andrew Polascik

(ABSTRACT)

Thirty-two Virginia Tech varsity football players served as subjects to examine the effect of protective knee braces on agility and selected isokinetic strength, power, and endurance measures. Each subject performed the Semo agility test in each of three experimental conditions: braced with the Anderson knee stabler (B-An); braced with the Arco knee guard (B-Ar); and unbraced (Un). The order of agility tests was randomized. The subjects were than administered a Cybex knee extension/flexion test at 60 deg/sec and 300 deg/sec. Each subject performed the Cybex tests in each of the three experimental conditions (B-An, B-Ar, and Un). The order of Cybex tests was randomized. The test protocol consisted of three maximal repetitions at 60 deg/sec and 40 maximal repetitions at 300 deg/sec. The following isokinetic variables were recorded: (1) peak

torque/body weight ratio of the quadriceps and hamstrings at 60 deg/sec and 300 deg/sec; (2) average range of motion for knee extension/flexion at 60 deg/sec and 300 deg/sec; (3) average power, torque acceleration energy, and endurance ratio of the quadriceps and hamstrings at 300 deg/sec. Repeated measures analysis of variance revealed no significant difference ($p > .05$) in agility test scores between the three experimental conditions. Repeated measures analysis of variance also revealed no significant difference ($p > .05$) in the isokinetic responses of subjects as they were tested within the three experimental conditions. The investigator concluded that protective knee braces had no effect on agility, isokinetic strength, power, and endurance.

ACKNOWLEDGMENTS

The Author would like to thank the following people for their contributions to the successful completion of this work:

My family for their continued love and support. My father's memory, for whom I loved and strongly miss. My wife, who was always their to help. Thanks dear for your patience, understanding, and encouragement.

who allowed me the opportunity to attend Virginia Tech. Thanks for your guidance and continued support. I will always have high regards for you as a professional trainer, and a friend.

Dr. Don Sebolt, whose help and generosity have enabled me to complete this task. I only hope that one day my students will have as much appreciation and respect for me as I have for him.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES CONT.

LIST OF FIGURES

Chapter I

INTRODUCTION

The knee joint is the largest and most complicated joint in the body. Since it is extremely unstable in terms of its bony arrangement due to the small tibial plateau, joint integrity is provided through the firm support of soft tissues such as ligaments and muscles.

This vital joint is commonly considered a hinge joint which performs two principle actions, knee flexion and knee extension. The knee is more than just a simple hinge joint, it is actually a "polycentric" joint where knee motions consist of a combination of rolling and sliding between the contacting tibial and femoral surfaces thus allowing the primary movements of knee flexion, extension, gliding, and rotation. (Izak, Jackson, & Townsend, 1987)

In competitive sports, the knee is in the flexed position far more than it is in extension. Therefore, the musculature of the knee becomes the last line of defense against injury. Muscles surrounding the knee need to be strong to help prevent injury when excessive force is placed on the knee joint. Maximizing muscle strength may help prevent some injuries, but it will not eliminate them. The severity of a knee injury depends not only on the strength level of the ahtlete, but also on the amount of stress placed upon the joint. Unless the musculature around the knee is in a state of contraction at the time of impact from an external force, the muscles can not contract rapidly enough to effectively protect the ligaments and the result is injury to the knee.

The most common knee injury occurs while the athlete has his knee slightly flexed, his foot planted, and his upper leg rotated outward. The knee is forced inward toward the opposite leg and the stress is primarily received in the ligaments on the inner side of the knee. (Davies & Wallace, 1980) The force is delivered to the lateral aspect of the knee resulting in possible injury to the medial collateral ligament, and possibly to the medial meniscus and the anterior cruciate liagment.

Knee injuries, are the most frequent injuries occuring in football. The average college football team should expect approximately five game related knee sprains, six practice related knee sprains, and two to three knee surgeries per season. (Powell, 1985) From 1978 through 1983, approxiamtely 75% of the injuries that occured in the National Football League that required surgery involved the knee. Almost 50% of these knee injuries resulted from blocking and tackling, while 30% of the injuries were caused by a teammate falling on another and were termed "accidental" injuries. The other 20% of the knee injuries occured without player contact. In 1984, a total of 119 NFL players underwent knee surgery. (Mihoces, 1985) In 1977, a survey conducted among high high school football players from six western states, revealed that knee injuries accounted for 12.7% of the total percent of injuries. (Pritchett, 1985)

Knee injury statistics for Virginia Tech Varsity Football from 1979 through the spring of 1985 totaled 138 knee injuries, 28 of which required surgery. Surgical procedures consisted of arthroscopic correction or ligament reconstruction. (Bullock, 1985)

Knee injuries, especially in football, may be prevented by increasing the strength and proprioception of the surrounding musculature of the knee joint, by wearing the proper shoes on the playing surface, and by utilizing protective or supportive devices. These protective devices or braces have been worn in the past to prevent further injury to an athlete's knee which had already been injured. There is an increasing trend toward football players wearing protective knee braces to help avoid an initial knee injury, and to help reduce the severity of a knee injury should it occur. These devices provide medial and lateral support, but do little for rotatory protection. (Klafs & Arnheim, 1981)

Efforts to reduce the risk of knee injury should be centered around reducing medial collateral ligament injuries since this ligament is the most often injured as well as the most frequent site for knee surgery. (Powell, 1985) Surgical repair to a damaged ligament cost approximately $3,500.00 and the athlete is lost for the remainder of the season. If knee braces are shown to help prevent injuries or lessen their severity when they do occur, then the minimum cost of the braces plus the possibility of a loss in mobility, outweigh the cost of knee surgery and the loss of a player.

<u>Statement of the Problem</u>

In the past, knee braces had been worn by athletes that had previously sustained trama to the knee. Today the use of knee braces has a new meaning; protection.

Athletes and coaches have expressed their concerns that the protective knee braces may limit an athlete's functional and muscular performance during activity. This suggests that their knee range of motion, strength, power, and endurace could be limited to some extent.

There also exists the possibility of some psychological implications due to wearing the protective knee braces. Some athletes may believe that their performance is impaired just because they are wearing protective devices on both of their uninjured knees.

This study was designed to investigate the effects of protective knee braces on agility and selected isokinetic parameters of strength and power. The protective knee braces that were examined included the Anderson knee stabler, and the Arco knee guard.

Muscular function of the knee was measured using the Cybex II Isokinetic Dynamometer. Specific measures recorded by the investigator included; peak torque of the knee extensors and flexors, range of motion at the knee joint, torque acceleration energy of the knee flexors and extensors, average power of the knee extensors and flexors, and endurance of the knee extensors and flexors. Agility was also measured using the Semo agility test.

Research Hypothesis

To delineate the purpose of this investigation, the following null hypotheses were established by the investigator:

1. There was no difference in agility when the knee was unsupported, supported with the Anderson knee stabler, or supported with the Arco knee guard.

2. There was no difference in peak torque/body weight ratio in isokinetic knee extension/flexion at 60 degrees per second joint angle velocity when the limb was unsupported, supported with the Anderson knee stabler, or supported with the Arco knee guard.

3. There was no difference in range of motion in isokinetic knee extension/flexion at 60 and 300 degrees per second joint angle velocity when the limb was unsupported, supported with the Anderson knee stabler, or supported with the Arco knee guard.

4. There was no difference in torque acceleration energy in isokinetic knee extension/flexion at 300 degrees per second joint angle velocity when the limb was unsupported, supported with the Anderson knee stabler, or supported with the Arco knee guard.

5. There was no difference in average power in isokinetic knee extension/flexion at 300 degrees per second joint angle velocity when the limb was unsupported, supported with the Anderson knee stabler, or supported with the Arco knee guard.

6. There was no difference in isokinetic knee extension/flexion at 300 degrees per second joint angle velocity when the limb was unsupported, supported with the Anderson knee stabler, or supported with the Arco knee guard.

Significance of the Study

Unpublished Studies by Tedeschi (1984), Johnson (1969), May, (1971), Hawkins (1977), and Martindale (1973) were conducted on individuals using protective knee braces. Agility, running speed, and leg muscle performance of the quadriceps and hamstrings were the dependent measures investigated by these researchers.

Tedeschi (1984) did report a small, but not statistically significant, decrease in performance when wearing the knee brace. The results from these investigations suggested that agility, running speed, and leg strength were not hampered by one wearing a protective knee brace.

Houston and Goemans (1981) studied the relationship between athletic performance and knee braces. Isometric torque of the quadriceps was measured at 90 degrees of knee flexion. Velocities of 30, 90, 180, and 300 degrees per second were used to measure dynamic torque. Power was measured using a short stair run. Mean maximal isokinetic contractions of the knee extensors were significantly lowered by 12 to 30% compared to corresponding values without the knee braces.
The data demonstrated that dynamic leg muscle performance can be impaired by the use of a knee brace.

Athletic departments are spending large sums of money to purchase protective knee braces in order to gain added protection for their athletes. These braces are worn with the belief that performance will not be limited by their usage. The results of this investigation will provide information regarding the effects of protective knee braces on agility and muscular function parameters of quadriceps and hamstring strength, endurance, power, torque acceleration energy and knee range of motion during flexion and extension.

Delimitations

The following delimitations were incorporated into the research design:

1. The study was restricted to thirty-two Virginia Tech varsity football players.

2. The Anderson knee stabler and the Arco knee guard were the only protective knee braces examined.

3. The muscular function parameters included quadricep and hamstring strength, endurance, power, torque acceleration energy, and knee range of motion during knee flexion and extension.

4. The performance parameter of agility was also examined.

Limitations

The following limitations were recognized by the investigator:

1. The subjects were participating in spring football practice during the time of data acquisition.

Basic Assumptions

The following assumptions were made by the investigator:

1. The subjects were not currently participating in a weight training program for the hip, low back, or legs during the time of the investigation.

2. The subjects were apparently healthy and free from any physical problems that might affect performance during experimental testing.

3. Each subject gave maximum effort during each of the experimental testing sessions.

Definitions of Terms and Symbols

AGILITY: The ability to change directions of the body or body parts rapidly while maintaining control of the body position and posture.

ANDERSON KNEE STABLER: Protective knee brace designed by Anderson which consists of a double hinge, with a center support bar made from lightweight steel.

ARCO KNEE GUARD: Protective knee brace designed by McDavid which consists of a single hinge and is made from hard plastic.

PREFERRED LEG: The leg which the athlete prefers to use when kicking a football or soccer ball for distance.

ENDURANCE: The percentage of change in work from the initial test repetitons to the terminal test repetitions.

PEAK TORQUE: The greatest torque produced during extension and flexion of the knee joint.

TORQUE ACCELERATION ENERGY (TAE): The amount of work performed in the first 1/8th second of torque production for the knee extensors and flexors.

AVERAGE POWER: Work per unit time - the total work done in the test repetitions divided by the total contraction time.

Summary

Injuries to the knee are serious and frequent in the course of sports, especially in football. To prevent knee injuries, an athlete can strengthen the musculature around the knee joint and also wear a protective knee brace.

Knee braces have previously been worn by those individuals who had sustained trama to the knee. Currently, there is a trend toward placing a brace on an uninjured knee for protection.

A ligament injury in football most often affects the medial collateral ligament. Protective knee braces may help prevent this type of ligament injury. While providing protection to the knee, these braces may limit specific muscular function and muscular performance parameters.

Several researchers have investigated the effect of protective knee braces on agility, running speed, and leg strength, and have suggested that these parameters are not hampered by the use of a protective knee brace. (Tedeschi 1984, Johnson 1969, May 1971, Hawkins 1977, & Martindale 1973)

This study was intended to investigate the effects of protective knee braces on the selected muscular function performance parameters. The experimental variables included: strength, endurance, torque acceleration energy, and average power of the knee extensors and flexors. Range of motion and agility were also examined. The protective devices used in this study were the Anderson knee stabler and the Arco knee guard.

CHAPTER II

REVIEW OF LITERATURE

This chapter has been organized into the following sections: 1) agility, 2) muscular strength, power, and endurance, 3) and knee braces.

Agility

The Brace's Motor Ability Test, the Cozen's Athletic Ability Test, and the Oregon Test are known by educators as popular motor ability tests. (Kirby, 1971) Each test is different, yet each test makes an attempt to define motor ability on the basis of certain specific motor skills. These skills are agility, strength, balance, eye hand coordination, etc.

Of these different aspects of motor ability, agility is considered as the most important component of motor ability. Agility can be defined as the "ability of a performer to change directions quickly and accurately." (Kirby, 1971) This change in direction is necessary for successful participation in all athletics. Coaches are spending significant amounts of time attempting to improve their players agility.

Cozens (1928) measured general athletic ability in fourty-one college men at the University of Oregon. The Dodge Run was used as the change of direction test for the purpose of measuring the speed of leg movement and the ability to change directions. Cozens suggested that the ability to change directions quickly was a quality important in all types of athletic events. (Gates & Sheffield, 1940)

Alden, Hoten, and Caldwell (1932) used a forty yard maze run to measure agility in three hundred-eleven college females while Gates & Sheffield (1940) used a forty yard maze test to measure types of motor ability in 7th, 8th, and 9th grade boys. May (1971) used a forty yard maze test to evaluate running agility in a study utilizing protective knee braces. The forty yard maze run has been used by investigators in the past as a change of direction test. In 1937, Young used the Howe Test, the Zig-Zag Run, and the Figure

Eight Test as change of direction tests for the evaluation of leg strength and its effects of agility. According to the results of the study, general body strength and leg strength do not have significant effects on the change of direction. (Gates & Sheffield, 1940)

Change of direction tests are valuable tools that can measure agility, but these tests are also very important because they possess the feature of adaptability. Other variables, besides agility, can be correlated and compared while agility is being measured.

Mohr and Haverstick (1956) correlated agility with Volleyball skills. Agility was measured by using a change of direction test, the Scott Obstacle Race. The study indicated that change of direction tests are not only a valid measure of agility, but can be used to measure variables which may affect sport performance.

Hilsendger, Straw, and Ackerman (1969) examined the relationship of agility to speed and strength. Change of direction tests were used to compare agility to speed and strength. The researchers concluded that agility was a unique factor and was not due to the interaction of speed and strength. This study also demonstrated the adaptability of a change of direction test.

Kirby (1971) developed a simple test for measuring agility for high school and college males. This agility test was called, the Semo agility test and was validated using the AAHPER Shuttle Run, and the Dodging Run. These tests were selected by Kirby because of their general acceptance by the profession as general measures of agility.

The Semo agility test is composed of many movement patterns which are required by an individual to use in an athletic event. These movement patterns are side stepping, back pedaling, and sprinting. The agility test was first designed to utilize the free throw area of a basketball court, with dimensions of 12 feet by 19 feet, but can be used on other surfaces which have adequate running space around the marked off dimensions.

The reliability of the test was reported to be R = .88 and the validity estimates between the Semo agility test and the AAHPER Shuttle Run, and the Dodging Run were reported to r = .63, and r = .72 respectively. The objectivity coefficient between two test administrator's scores for the Semo agility test was reported to be r = .97. According to the data reported by Kirby, the Semo agility test was a reliable and highly objective measure of agility.

Muscular Strength

Muscular strength is the ability of a muscle or muscle group to exert maximal force in a single voluntary effort. Strength is also recognized as a major component of success in athletic participation.

Athletes need strength to varying degrees depending on the sport in which they participate. Strength is needed not only to be a successful athlete, but to also avoid from sustaining an injury during athletic participation. Wilmore (1975) defined strength as the ability to apply or resist force. This ability to resist force may help an individual avoid injury.

Dynamic muscular strength has been commonly measured by the amount of weight that can be successfully lifted once (one repetition maximum: 1RM). This is the amount of weight an individual can lift one time. Lifting weights in this manner is a form of an isotonic exercise. In an isotonic exercise, maximal tension is only placed on a muscle during a small portion of the range of motion during the exercise. Therefore, the total work done in this type of exercise is significantly less than when a maximal tension is required throughout the range of motion, as demonstrated in an isokinetic exercise.

Isokinetic devices are now being used for muscle strength testing and training. These devices keep the speed of the movement constant and allows an individual to maximally load his muscles throughout an entire range of motion. With isokinetic devices, the amount of torque that can be generated is measured at various speeds since the tester has the ability to control the velocity of the muscular contraction.

Peak torque is expressed as the highest recorded value on the torque curve produced in the entire range of joint motion in an exercise on the isokinetic system. This is the most commonly used parameter as a measure of strength on an isokinetic system. Peak torque can also be expressed as a percentage of bodyweight. This ratio has become a tool for inter-individual comparisons, and also for evaluation of one's functional strength.

Endurance is a function of one's strength over time or repetitions, and can be accurately measured using an isokinetic system. The endurance ratio of a muscle group is calculated as the muscle becomes fatigued during exercise. Predetermined number of repetitions are sampled at the beginning and end of an exercise test. The percentage of change in work from the initial to the terminal repetitons is computed to represent the endurance ratio. This ratio expresses the degree to which an individual fatigued during the isokinetic test. Cybex recommends sampling 20% of the total preselected endurance repetitons to provide a consistant sample for reproducible data collection. (Cybex, 1983) An endurance test consisting of 40 repetitions has been suggested by Davies to be used to evaluate the endurance ratio of high performance athletes. (Davies, 1984)

Muscular strength, muscular endurance, and muscular power are all aspects of muscular performance. Isokinetic devices such as Cybex have the capability to measure muscular power that is needed in sporting activities. Torque Acceleration Energy, or TAE, is the period where an individuals force ouput is accelerating the most. In the first 1/8th second of torque production, the amount of work performed is calculated and expressed in ft-lbs of work. This measure of the initial power has been recommended to be evaluated at the fastest test speed available, 300 deg/sec joint angle velocity. (Cybex, 1983)

Studies have suggested that isokinetic training procedures may produce significant strength and power gains. (Pipes & Wilmore, 1975) Isokinetic devices allow for maximal dynamic loading throughout the entire joint range of motion. The resistance experienced by an individual exactly matches the force produced by an individual throughout the entire range of motion. Therefore, maximal resistance occurs throughout the range of motion in order to keep the velocity of the exercise at a constant rate.

Another important factor of the isokinetics is the ability to approximate training speed. Most functional activities occur at fast contractile velocities. As the body prepares the leg for weight acceptance during gait, the knee extends at a rate of 233 degrees per second. (Anna, Edwards & Wyatt, 1981) During running, the velocity of movement at the knee joint is approximately

400 degrees per second to 1200 degrees per second. (Davies, 1984) Therefore, to be functionally rehabilitated for walking only, the quadriceps need to be exercised at speeds between 200 degrees per second and 300 degrees per second. (Anna, Edwards, & Wyatt, 1981)

Rockwell revealed from football injury studies that the medial collateral ligament sustained injury when the knee motion was at a velocity of 320 degrees per second. (Rockwell, 1984) Slow training speeds will not develop the muscles power and strength needed to protect the knee joint when forces occur at high velocities. Not only could it be possible to prevent injury by training the musculature around a joint at speeds where specific skills are employed, but it might be possible to influence athletic performance by training the muscles at speeds approximating skill speeds used in sports.

Original studies on isokinetics conducted muscle tests at speeds of 120 degress per second or slower. (Davies, 1984) Studies are currently reporting data from tests utilizing speeds of 180 degrees per second to 300 degrees per second. (Anna, Edwards, & Wyatt, 1981, Davies, 1984)

The Cybex II, an isokinetic system which was introduced in 1970, has assumed the role as the leader in muscle strength testing, athletic screening, injury evaluation, and athletic rehabilitation. McMorris and Elkins (1985) described isokinetics as regulation of the movement speed. Isokinetics will allow a muscle group to produce maximal torque while the movement speed is kept constant.

Several studies have investigated the reliability and validity of the Cybex. Hart, Barber, and Davis (1981) used a microprocessor which recorded an analog signal from the Cybex II to improve the accuracy in the measurement of torque produced during exercise. The estimated reliability for this system was reported as $R = .99$.

In 1982, Richards and Cooper interfaced an Apple microcomputer to the Cybex II dynamometer and computed instantaneous values for torque, power, and work. Intraclass reliability coefficients for the measured parameters were reported to range from $R = .991$ to $R = .999$.

Johnson and Siegel (1978) investigated the reliability for the mean of the last three out of six testing trials for knee extension to be R = .98.

In 1988, Susan Earles-Price reported the stability reliability (test/retest) estimate produced on the Cybex by the knee extensors ranged from R = .75 - .92 for the measures of peak torque and work.

In 1982, Mawdsley and Knapik investigated isokinetic contractions of the knee extensor muscles of males and females. These investigators reported no significant difference was found in peak torque across trials.

Knee Braces

It is estimated that over 70,000 protective knee braces are currently used by football players. (Mihoces, 1985) The objective of lateral protective bracing is to lower the frequency and severity of knee injuries. Coaches and trainers are requiring their healthy athletes to wear these protective devices during practice and competition. These braces could serve as the "technological breakthrough in the war against the ultimate football injury." (May, 1985)

Today, a college football player has a higher probability of sustaining a sports injury. Even playing surfaces have been changed to allow the game to continue an eliminate natures influence on the games velocity.

Data recorded by the National Injury Reporting System revealed that the medial collateral ligament of the knee has the highest rate of injury over the specific ligaments of the knee. (Powell, 1985) Game conditions also produces a higher frequency of injury than practice conditions. (Powell, 1985) The NCAA is currently considering making the use of protective knee braces mandatory in the near future, especially for game situations. The San Fransico 49ers were the first National Football League team that made the use of protective knee braces mandatory for all of their linemen. (Caraska, 1985)

Knee braces have been designed to provide needed support and protection for the knee. Lateral protective braces also provide this support and protection, but do this with the idea of not compromising an athlete's mobility. Professional players have been reported as disliking protective braces because they fear the brace will reduce their speed and agility. (FitsGerald, 1984)

Nwaobi (1980) examined what effects bracing, elastic taping, non-elastic taping had on medial knee stability in twenty male athletes. Lateral deviation of the tibia on the femur was measured before and after the application of the elastic, non-elastic tape, and the hinged metal brace.

This study reported a significantly reduced lateral deviation prior to activity, but only the metal brace and the non-elastic tape significantly decreased lateral deviation of the knee after activity. After activity the elastic tape had lost 39.6% of its effectiveness, the non-elastic tape lost 38.7% of its effectiveness, and the metal hinged brace lost only 17.6% of its effectiveness. It was concluded that a frequently used metal hinge brace before or even after activity is effective in reducing lateral deviation of the knee.

Anderson, (Omni Scientific, 1984) designed a knee brace which was a double hinged, single sided brace with a center support bar made from lightweight steel. A hyperextension stop is also a feature of the brace. This brace was initially designed to protect football players, but has become the most widely used lateral knee brace for all sports. The Anderson knee stabler is usualy worn on the lateral side of the knee in order to protect the medial collateral ligament and the medial capsule of the knee.

Another lateral knee brace on the market is the Arco knee guard designed by McDavid. (McDavid, 1985) This brace is a single axis hinge brace made from a lightweight polycarbonate. This plastic is designed to give under stress absorbing kinetic energy like a shock absorber. This brace is also equipped with a hyperextension stop.

Most often these protective braces are used by football lineman. These athletes are often exposed to lateral blows to the knee. But there is still question on how these braces effect running speed, agility, knee range of motion, power, strength, and endurance.

Houston and Goemans (1981) studied the relationship between athletic performance and knee braces. Seven male athletes were given a battery of tests on the Cybex II isokinetic dynamometer. Isometric torque was measured at 90 degrees of knee flexion. Velocities of 30, 90, 180, and 300 degrees per second were used to evalute dynamic torque. Vertical velocity (power) was measured using a short stair run. Blood lactate was also measured before and after an endurance test using a bicycle ergometer. isokinetic contractions of the knee extensors were significantly lowered by 12% to 30% compared to corresponding values without the knee braces. The data demonstrated that dynamic leg muscle performance can be impaired by the use of the knee braces. Performance on the stair run without the knee brace was significantly ($p > .01$) improved. These results suggest that potential benefits of support braces may come at the expense of performance. Each subject had previous knee injury and had either worn a Lenox-Hill brace, a Toronto brace, or a Kelly brace prior to the study.

Tedeschi (1984) examined the effects of the Anderson knee stabler on various components of knee function, agility, and strength. Six male varsity football players were selected for the study. An Semo agility test was administered to each subject with and without the use of the Anderson knee stabler in the braced condition. Velocities of 30, 90, 180, and 300 degrees per second were used to evaluate dynamic torque on the Cybex II Isokinetic Dynamometer. At

300 degrees per second, there was a sharp decrease in torque production when the knee brace was worn. The results of the agility test reported a small decrease in performance when wearing the knee brace. However, none of the results were reported as statistically significant.

Johnson (1969) examined the effects of the Arco knee guard on agility. A forty yard maze run was used to evaluate agility. Fourteen graduate students were subjects in the study. Each subject was timed in the maze run with an without the Arco knee guard. The brace was applied to the left leg of the subjects during the testing. No significant difference was reported between the braced and the unbraced subjects.

The effect of the Arco knee guard upon agility was also examined by May (1971). A forty yard maze run was administered to thirteen graduate students. Each student wore the knee guard on the right knee during testing procedures. No significant difference was reported by the investigator.

Hawkins (1977) examined the effect of the Arco knee guard on running speed. Running speed was determined by timing subjects in a thirty yard sprint. The Arco knee guard was worn on the knee of the subject's dominant leg during testing. No significant difference was reported in this investigation.

Summary

Kirby (1971) developed a simple test for measuring agility. This test, the Semo agility test, was reported to be a reliable and objective measure of agility which could be used on any running surface that has adequate running space. This agility test is composed of many movement patterns which are required by an individual in athletic competition.

Nohr and Haverstick (1956) correlated agility with Vollyball skills. Hilsendger, Straw, and Ackerman (1969) examined the relationship of agility to speed and strength. These investigators concluded that change of direction tests are a valid indicator of agility.

Tedeschi (1984), Johnson (1969), May (1971) and Martindale (1973) examined the effects of protective knee braces on individuals agility performance and concluded that these braces did not alter ones agility performance.

Muscular strength, muscular endurance, and muscular power are components of successful athletic participation. These muscular parameters can be measured by isokinetic devices such as the Cybex Isokinetic Dynamometer. These parameters are highly reproducible and can be used for both within and between subject comparisons.

Isokinetic devices are superior in producing greater strength gains than other traditional methods, and allow one to approximate training speeds. (Pipes & Wilmore, 1975) Most functional activities occur at fast contractile velocities. The Cybex allows one to train and be tested at the speed which these functional activities occur.

Traditionally, athletes have worn functional knee braces only for support due to ligamentous laxity. Now individuals are wearing knee braces to avoid injury to their knee. According to the manufacturer of these protective knee braces, the braces not only protect the knee from contact loading and medial collateral ligament injuries, they also provide lateral, rotational, anterior, and posterior stability without having an effect on one's mobility and speed.

Two popular protective knee braces available to the athlete are the Anderson knee stabler and the Arco knee guard. Tedeschi (1984) examined the effects of the Anderson knee stabler on agility and muscular strength in six college football players. Agility was tested by the use of the Semo agility test. Muscular strength was measured as peak torque on the Cybex at speeds of 30, 90, 180, and 300 degrees per second. It was reported that there was a sharp decrease in torque production at 300 degrees per second. However, no significant differences were reported for agility and muscular strength when examined in its braced and unbraced conditions.

Johnson (1969) and May (1971) examined the effects of the Arco knee guard on agility by using a forty yard maze run test. Subjects were tested with and without the Arco knee guard. The brace was worn on one leg during the braced condition. No significant difference was reported between the braced and unbraced conditions.

Hawkins (1977) examined the effects of the Arco knee guard on running speed in a thirty yard sprint. The Arco knee guard was worn on the subjects dominant leg. No significant difference was reported between the braced and unbraced conditions.

CHAPTER III

JOURNAL MANUSCRIPT

THE EFFECT OF PROTECTIVE KNEE BRACES ON AGILITY AND MUSCLE PERFORMANCE

Michael A. Polascik

ABSTRACT

Thirty-two Virginia Tech varsity football players served as subjects to examine the effect of protective knee braces on agility and selected isokinetic strength, power, and endurance measures. Each subject performed the Semo agility test in each of three experimental conditions: braced with the Anderson knee stabler (B-An); braced with the Arco knee guard (B-Ar); and unbraced (Un). The order of agility tests was randomized. The subjects were than administered a Cybex knee extension/flexion test at 60 deg/sec and 300 deg/sec. Each subject performed the Cybex tests in each of the three experimental conditions (B-An, B-Ar, and Un). The order of Cybex tests was randomized. The test protocol consisted of three maximal repetitions at 60 deg/sec and 40 maximal repetitions at 300 deg/sec. The following isokinetic variables were recorded: (1) peak torque/body weight ratio of the quadriceps and hamstrings at 60 deg/sec and 300 deg/sec; (2) average range of motion for knee extension/flexion at 60 deg/sec and 300 deg/sec; (3) average power, torque acceleration energy, and endurance ratio of the

quadriceps and hamstrings at 300 deg/sec. Repeated measures analysis of variance revealed no significant difference ($p > .05$) in agility test scores between the three experimental conditions. Repeated measures analysis of variance also revealed no significant difference ($p > .05$) in the isokinetic responses of subjects as they were tested within the three experimental conditions. The investigator concluded that protective knee braces had no effect on agility, isokinetic strength, power, and endurance.

INTRODUCTION

Knee injuries remain the most common serious injury occuring in football. The number of knee injuries can be reduced by increasing the strength and proprioception of the surrounding musculature of the knee joint, by wearing the proper shoes for a given surface, and by utilizing protective or supportive devices.

Protective devices or braces are normally worn to help prevent further injury to an already compromised limb. However, there is an increasing trend toward football players wearing protective knee braces to help avoid an initial episode of knee injury, and to help reduce the severity of a knee injury should it occur. It is estimated that over 70,000 protective knee braces are currently used by football players in professional, college, and high school athletics. (Mihoces, 1985) Two popular protective knee braces available to the athlete are the Anderson knee stabler and the Arco knee guard.

This study was designed to investigate the effects of protective knee braces on selected muscular function parameters of agility and the isokinetic variables of peak torque/body weight ratio, range of motion, torque acceleration energy, average power, and endurance.

PROCEDURES

Thirty-two male Virginia Tech varsity football players volunteered to participate in this investigation. Each participant read and signed an informed consent and completed medical screening prior to participation in the study.

Each subject completed an agility familiarization prior to the beginning of the Semo agility testing. Subjects were tested in only one experimental condition per day which allowed warm up trials, and three maximal test trials with a three minute rest period between trials. Testing was conducted in an indoor astroturf facility. Agility testing involved an unbraced condition, both knee braced with the Arco knee guard, and both knees braced with the Anderson knee stabler.

Cybex Testing:

Subjects participated in a familiarization session on the Cybex II prior to the Cybex testing sessions.

Each subject completed an Isokinetic evaluation at 60 degrees per second joint angle velocity, and 300 degrees per second joint angle velocity wearing an Arco knee guard, and a Anderson knee stabler. Evaluation was also conducted in an unbraced condition. Subjects were tested in only one experimental condition per day and were allowed a minimum of 2 days rest prior to the next testing session. Ample warm-up was allowed during the Isokinetic testing. At the 60 degree per second joint angle velocity test speed, peak torque/body weight ratio of the quadriceps and hamstrings were examined in each experimental condition. Average knee range of motion for knee extension and flexion was also evaluated in each condition. At the 300 degree per second joint angle velocity test speed, parameters evaluated in each of the three experimental conditions were peak torque/body weight ratio, average range of motion, average power, torque acceleration energy, and endurance. These parameters were examined for both knee extension and knee flexion. Testing data for both testing speeds was recorded by the Cybex data reduction computer.

RESULTS

A repeated measures analysis of variance was used to calculate intraclass reliability for the scores recorded from the Semo agility test. Each of the conditions produced reliability estimates greater than R = .90. A repeated measures one way analysis of variance was used to determine if significant agility times were recorded across the conditions. No significant differences ($p > .05$) were found between the three experimental conditions in agility scores. Figure 1. displays the agility test scores.

The Cybex knee extension/flexion test evaluated speeds of 60 and 300 degrees per second joint angle velocity under the three experimental conditions. The Cybex measures recorded at the test speed of 60 deg/sec included: peak torque/body weight ratio and average range of motion. A repeated measures analysis of variance was used to determine if peak torque/body weight ratio and average range of motion were a function of the experimental conditions. No significant difference ($p > .05$) was found between the three test conditions for peak torque/body weight ratio for knee extension and knee flexion. The test results are displayed in Figure 2.

Figure 1.

Semo Agility Test Results

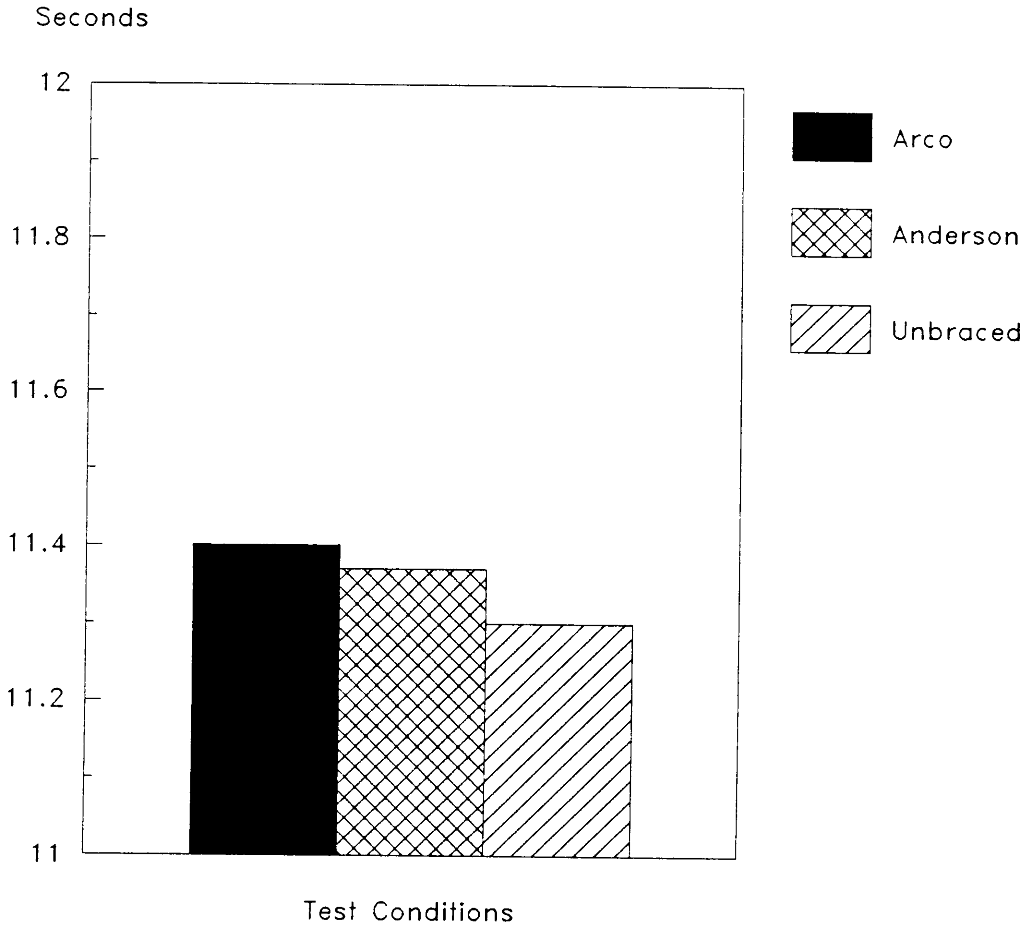
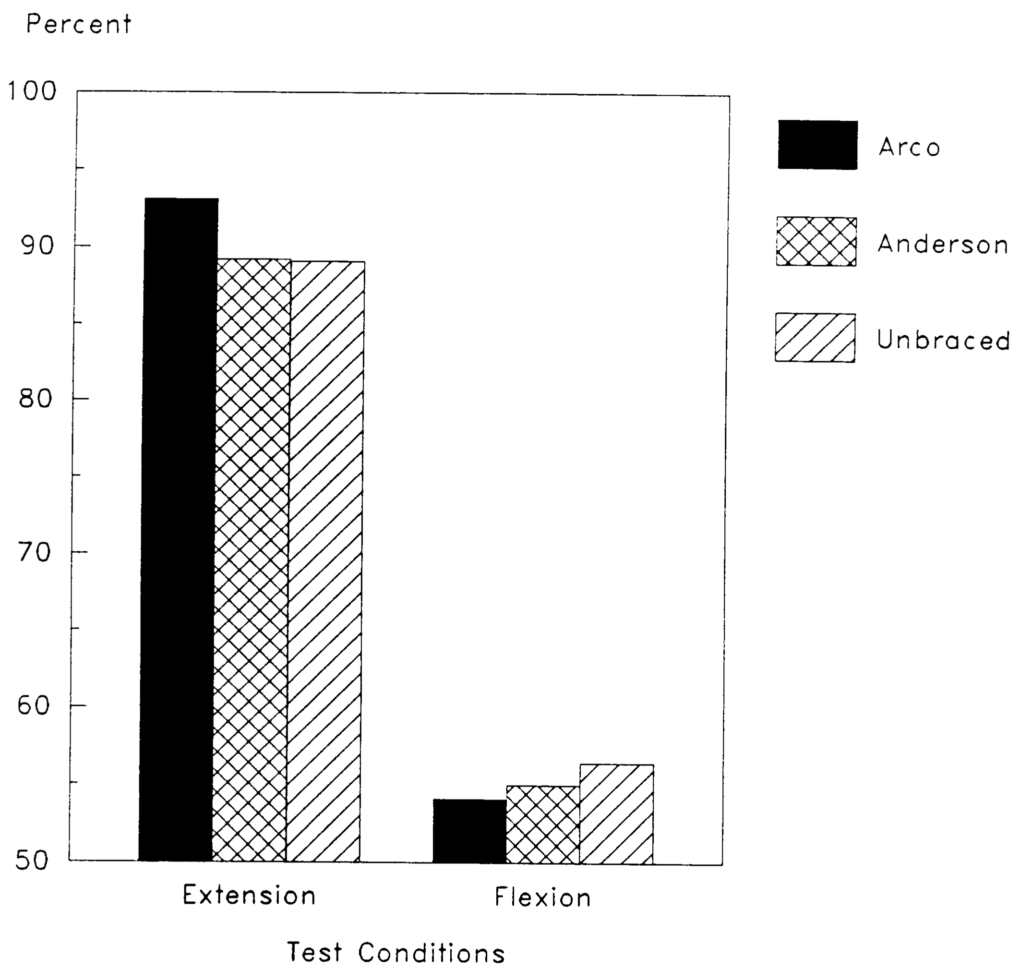


Figure 2.

Peak Torque/Body Weight Ratio at 60 Deg./Sec.



No significant difference ($p > .05$) was found between the three experimental conditions and average range of motion for knee extension and knee flexion. These test results are displayed in Figure 3.

The variables recorded at 300 degrees per second joint angle velocity included: peak torque/body weight ratio, torque acceleration energy, average power, average range of motion, and endurance. A repeated measures analysis of variance was used to determine if peak torque/body weight ratio, torque acceleration energy, average power, average range of motion, and endurace were a function of the experimental conditions. No significant difference ($p > .05$) was found between the experimental conditions and peak torque/body weight ratio for knee extension and knee flexion. The test results are displayed in Figure 4. No significant difference ($p > .05$) was reported between the three experimental conditions and torque acceleration energy for knee extension and knee flexion. These results are displayed in figure 5. No significant difference ($P > .05$) was reported between the three experimental conditions and average power for knee extension and knee flexion. These results are displayed in Figure 6.

Figure 3.

Average Range of Motion at 60 Deg./Sec.

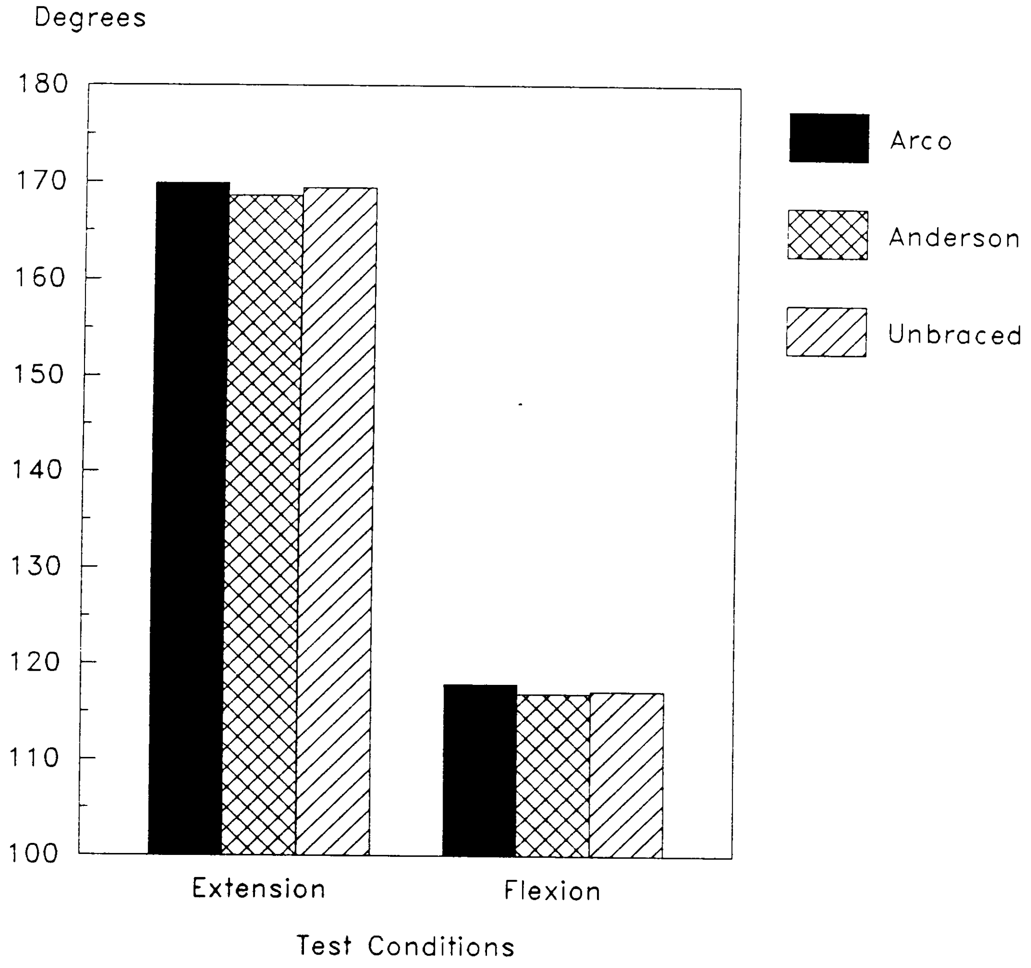


Figure 4.

Peak Torque/Body Weight Ratio at 300 Deg./Sec.

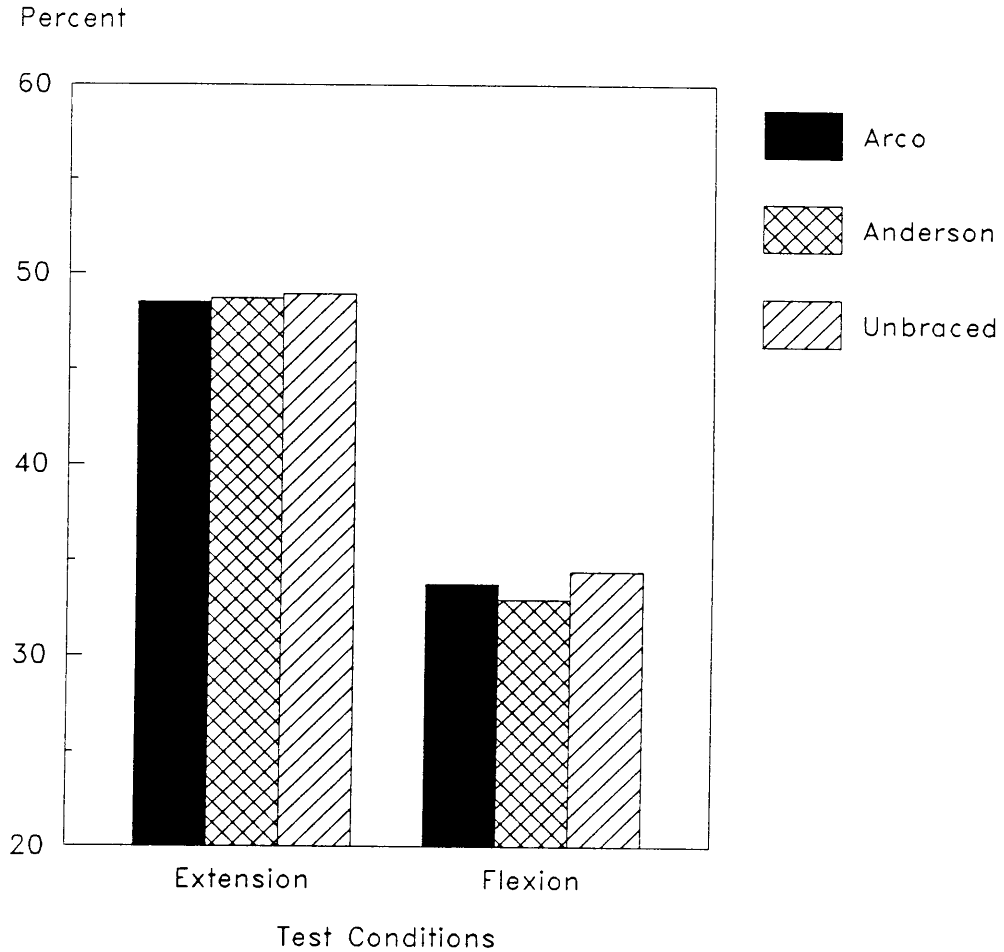


Figure 5.

Torque Acceleration Energy at 300 Deg./Dec.

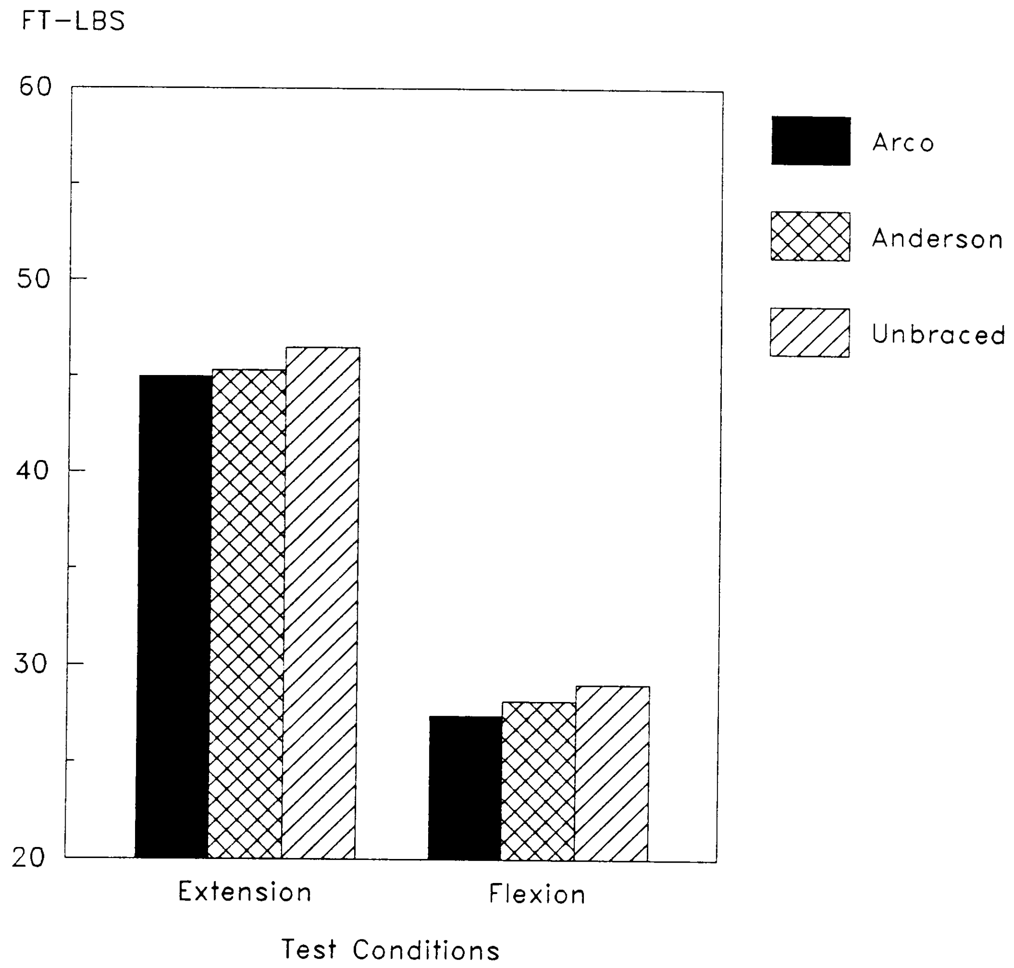
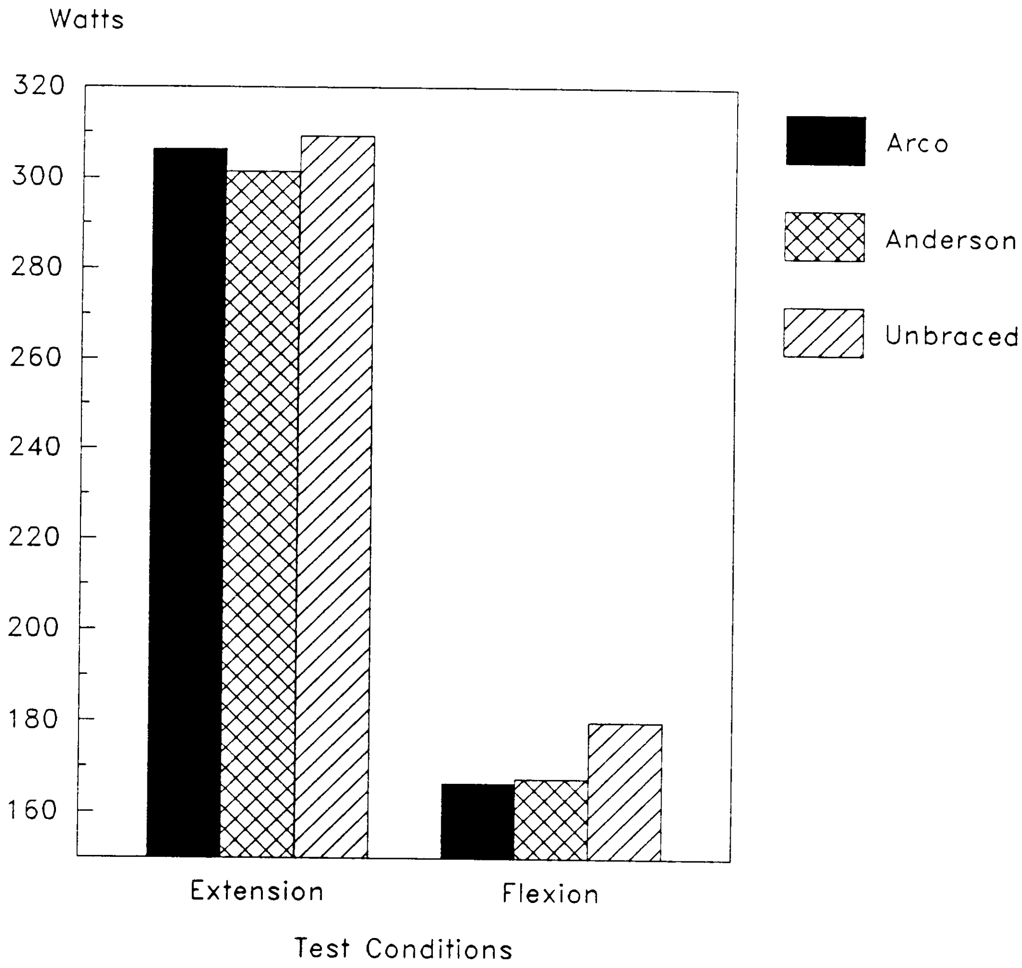


Figure 6.

Average Power at 300 Deg./Sec.



No significant difference ($p > .05$) was reported between the three experimental conditions and average range of motion for knee extension and knee flexion. These results are displayed in Figure 7. No significant difference ($p > .05$) was reported between the three experimental conditions and endurance for knee extension and knee flexion. These results are displayed in Figure 8.

Figure 7.

Average Range of Motion at 300 Deg./Sec.

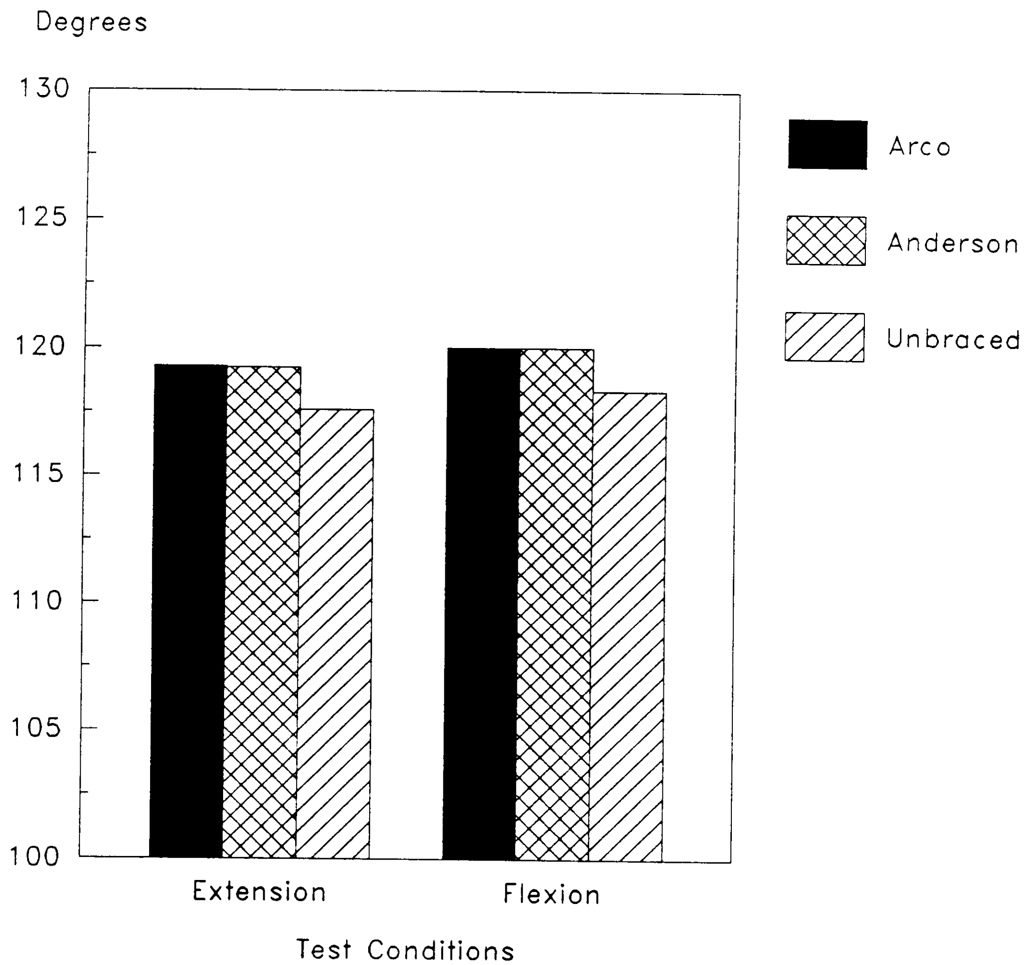
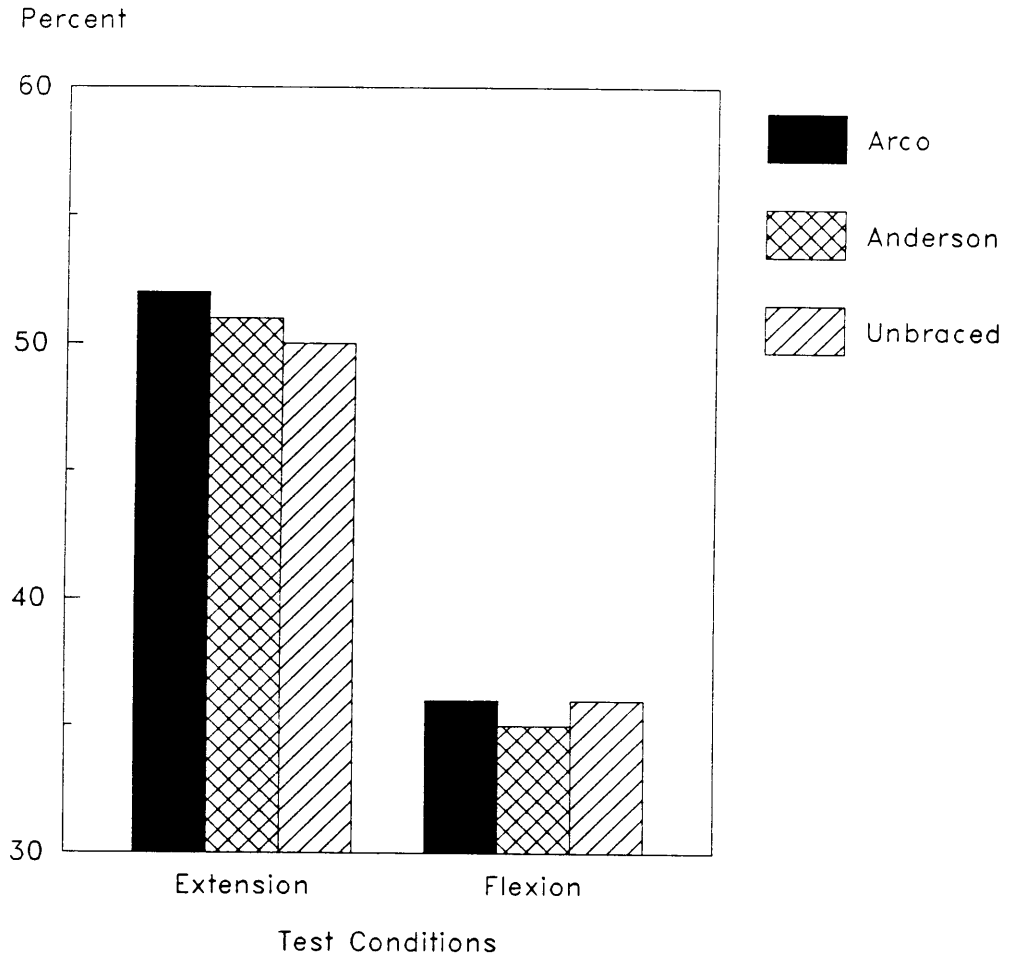


Figure 8.

Endurance Ratio at 300 Deg./Sec.



Discussion

Kirby (1971) developed the Semo agility test which is composed of many movement patterns which are required by an individual in athletic competition. He determined that this agility test was reliable R = .97, and a highly objective measure of agility. The reliability in this investigation for the Semo agility test was found to be R = .90.

Straight ahead sprinting is one component of the Semo agility test. Hawkins (1977) examined how the Arco knee guard affected running speed. He concluded that the Arco knee guard had no significant affect on running speed.

Tedeschi (1984) examined the effects of a protective knee brace on agility using a Semo agility test. There were no significant differences in the agility scores reported between the braced and unbraced conditions. But there was a small, not significant, decrease in performance found in the braced condition. The results of this investigation are in agreement with those of Tedeschi. No significant difference was found between the braced and unbraced agility scores. This investigator did note that the agility scores from the unbraced condition were slightly faster than the scores from the braced condition. This finding is also in agreement with Tedeschi's findings.

Johnson (1969), May (1971), and Martindale (1973) also investigated what effects, if any, a protective knee brace had on agility using the 40 yard maze run. The reliability of this change of direction test was reported to be R = .954. (McCloy and Young, 1954) These investigators reported no evidence to support their hypothesis that a protective knee brace will have an effect on agility performance.

Change of direction tests are valuable tools used to measure agility. Both the 40 yard maze run and the Semo agility test evaluate change of direction. The findings in this investigation from the change of direction tests are in agreement with those findings of Johnson (1969), May (1971), and Martindale (1973).

Houston and Goemans (1981) evaluated dynamic torque production from a braced and unbraced knee on the Cybex II isokinetic dynamometer. These investigators reported significantly lower values for maximal torque production in the braced condition at joint angle velocities of 30, 90, 180, and 300 degrees per second.

In this investigation, peak torque was evaluated in relation to the subjects body weight. This investigator reported no significant difference in the peak torque/body weight ratio at joint angle velocities of 60, and 300 degrees per second.

The findings from this investigation are not in agreement with those findings of Houston and Goemans (1981). This is probably due to the fact that Houston and Goemans evaluated torque production from individuals who had knee ligamentous instability and wore a functional knee brace during testing where this investigator evaluated torque production of healthy subjects while wearing a protective knee brace.

Tedeschi (1984) examined the effects of a protective knee brace on peak torque produced by the quadriceps at joint angle velocities of 30, 90, 180, and 300 degrees per second. The investigator concluded that a protective knee brace did not affect peak torque produced by the quadriceps at the various knee joint angle velocities. Torque values for the braced condition were higher than the unbraced condition for each of the joint angle velocities examined. This was attributed to the subjects being unfamiliar with the

Cybex II apparatus. The subjects were tested in the unbraced condition first, and may have become accustomed to the isokinetic resistance when testing in the braced condition and a learning affect occurred.

This investigators findings are in agreement with those of Tedeschi's. The Anderson knee stabler does not affect torque production at the joint angle velocity of 300 degrees per second for the quadricep musculature. This investigator also concluded that the Arco knee guard does not affect torque produced by the quadricep musculature at the joint, angle velocity of 300 degrees per second. Torque production of the hamstring musculature was also evaluated at knee joint angle of 300 degrees per second and the quadriceps at 60 degrees per second. It was concluded from the results that that neither the Arco knee guard or the Anderson knee stabler had an affect on torque produced by the hamstring and quadricep musculature.

Other muscle performance parameters were investigated in this study. It was concluded from the results that neither the Anderson knee stabler or the Arco knee guard have an affect on knee range of motion, torque acceleration energy, average power, and endurance of the quadriceps and the hamstring musculature.

Summary

This investigation examined the effects of the Arco knee guard and the Anderson knee stalber on agility and selected muscle performance parameters. This investigation produced no significant difference between the scores of the two braced conditions, and the unbraced condition for the Semo agility, or for the isokinetic variables measured by the Cybex.

This investigator's findings are in agreement with Tedeschi (1984), Hawkins (1977), Johnson (1969), May (1971), and Martindale's (1973) reported findings and in disagreement with those of Houston and Goemans (1981).

REFERENCES

Hawkins, H. A. (1977). The Effect Of The Arco Knee Guard On Running Speed. Unpublished master's thesis, Indiana State University, Terre Haute, Indiana

Houston, M. E., & Goemans, P. H. (1981). Leg Muscle Performance of Athletes With and Without Knee Support Braces. Archives of Physical Medicine and Rehabilitation, 63, 431-432.

Johnson, A. (1969). The Effects Of Wearing A Knee Guard On Agility. Unpublished master's thesis, Indiana State University, Terre Haute, Indiana

Kirby, R. (1971). A simple Measure of Agility. Coach & Athlete, 30-31.

May, T. L. (1971). Effect Of The Arco Knee Guard Upon Agility Determined By The Forty Yard Maze Test. Unpublished master's thesis, Indiana State University, Terre Haute, Indiana

Martindale, A. (1973). Effect Of The Arco Knee Guard On Agility. Unpublished master's thesis, Indiana State University, Terre Haute, Indiana

McCloy, C. H., & Young, N. D. (1954). Tests and Measurements in Health and Physical Education. New York Apleton-Century-Crofts.

Mihoces, G. (1985, January 11). Knee injuries stagger some of NFL's best. USA Today, p.1.

Tedeschi, A. J. (1984). The Effect Of The Anderson Knee Stabler On Various Components Of Knee Function. Unpublished master's thesis, University of the Pacific, Stockton, California

CHAPTER IV

SUMMARY OF THE STUDY

This study investigated the effect of the Arco knee guard and the Anderson knee stabler on agility and selected muscle performance parameters. Thirty-two Virginia Tech varsity football players volunteered to perform nine agility tests in an indoor astroturf facility, and three knee extension/flexion tests on the Cybex II isokinetic dynamometer. The Semo agility test protocol consisted of three trials in the Arco braced condition, three trials in the Anderson knee stabler, and three trials in the unbraced condition. Test protocol for the knee extension/flexion test consisted of 3 maximal repetitions at 60 degrees per second joint angle velocity, and 5 maximal repetitons at 300 degrees per second. A 40 maximal repetition endurance test was also performed at 300 degrees per second.

The following parameters were recorded by the Cybex data reduction computer: (1) peak torque/body weight ratio of the quadriceps and hamstrings at 60 degrees per second; (2) average range of motion of knee extension/flexion at 60 degrees per second; (3) peak torque/body weight ratio of the quadriceps and hamstrings at 300 degrees per second; (4) average range of motion for knee extension/flexion at 300 degrees per second: (5) average power of the quadriceps and hamstrings at 300 degrees per second; (6) torque acceleration energy of the quadriceps and hamstrings at 300 degrees per second; (7) endurance ratio of te quadriceps and hamstrings at 300 degrees second second.

A two-way repeated measures analysis of variance across each experimental condition was implemented to determine the criterion score. A significant difference existed between the agility trials, therefore, the best score was selected as the criterion score for each subject in each experimental condition.

A repeated measures analysis of variance was used to calculate intraclass reliability for the agility testing scores. Each of the three conditions produced reliability estimates greater than R = .90.

A one-way analysis of variance was used to test the hypothesis of no difference in agility or in the muscular parameters examined across the three experimental conditions. Results of the one-way ANOVA allowed the investigator to conclude no statistical significant difference was found in the agility scores between the braced and unbraced condition, or the agility scores between the two braced conditions. Results of the one-way ANOVA allowed the investigator to conclude no statistical significant difference was found between the braced and unbraced condition, or between the two braced conditions for any of the muscular performance parameters examined at 60 and 300 degrees per second joint angle velocity.

Research Implications

The results of this study indicate that the Arco knee guard and the Anderson knee stabler do not hinder a football players agility, running speed, muscular strength, muscular power, knee range of motion, and muscular endurance.

Since both the single and double-hinge design were investigated in this study, it is concluded that other protective knee braces with the same design specifications may not hinder ones performance.

The conclusions from this study suggest that individuals who use these protective knee braces should disregard their concerns regarding detrimental effects on performance. They should direct their concerns toward these issues: 1) do these braces decrease or increase the injury rate of the knee joint? 2) are individuals and athletic departments spending large sums of money on a product that does not work? 3) are other ligamentous structures of the knee pre-loaded by the use of these braces? 4) are we outweighing the importance of protective knee braces over conditioning and strengthening of the musculature surrounding the knee in order to decrease the injury rate of the knee? 5) are we giving these athletes a false sense of security by wearing a protective knee brace?

Recommendations for Future Research

The following recommendations for further study are suggested:

1) A long term investigation of the injury rate of the knee, ankle, and hip among college, professional,

and high school football players to provide information on the efficacy of these braces.

2) Investigation of the injury rate among athletes of other sports who use protective knee braces.

3) Biomechanical studies using protective knee braces which investigate the possibility of pre-loading the medial collateral ligament or other ligaments by using a protective knee brace.

4) Investigation to determine which type of brace best absorbs and distributes contact forces.

REFERENCES

Anderson, G. (1977). The Anderson Knee Stabler. _The Physician and Sportsmedicine_, _7_, 125-127

Alden, F. D., Horton, M. O., & Caldwell, G. M. (1932). A Motor Ability Test for Women for the Classification of Entering Students into Homogeneous Groups. _Research Quarterly_, _3_, 86-119.

Ary, D., Jacobs, L. C., & Razavieh, A. (1979). _Introduction to Research in Education_ (2nd Ed.). New Youk: Holt, Rinehart and Winston.

Brace, D. K. (1946). Studies in Motor Learning of Gross Bodily Motor Skills. _Research Quarterly_, _17_, 242-253.

Bullock, R. (1985). _Knee Injury Statistics for Va. Tech Varsity Football_. Unpublished manuscript.

Caraska, E. (1984, July 23). Critical Injuries Last Year Move Walsh to Require Knee Braces For Lineman. _The Sacramento Bee_. p. 42.

Chandler, J. V., Langley, T., & Blair, S. (1967). Movement Times for Jab and Cross-Over Steps by High School Football Players. The Research Quarterly, 46, 147-152.

Computerized Isolated-Joint Testing: A Handbook for Using the Cybex Data Reduction Computer. (1983). Ronkonkoma NY: Cybex.

Davies, G. (1984). A Compendium of Isokinetics in Clinical Usage. Wisconsin: S and S Publishers.

Davies, G. J., & Wallace, L. (1980). Mechanisms of Selected Knee Injuries. Physical Therapy, 60, 1590-1595.

Earles-Price, S. N., Sebolt, D., & Herbert, W. G. (1989) Reliability Estimates of Isokinetic Torque Curves Using Segmental Analysis. Research Abstract. International Isokinetic Congress. Lake Tahoe, Nevada.

FitsGerald, T. (1984, October 30). Mandatory Knee Braces for Players. San Francisco Chronicle, p. 22.

Gates, D. D., & Sheffield, R. P. (1940). Tests of Change of Direction as Measurements of Different Kinds of Motor Ability in Boys of the Seventh, Eighth, and Ninth Grades. Research Quarterly, 11, 136-147.

Hart, D. L., Barber, D. C., & Davies, H. (1981). Cybex II data acquisition system. Journal of Orthopaedics and Sports Physical Therapy, 2, 177-179.

Hawkins, H. A. (1977). The Effect Of The Arco Knee Guard On Running Speed. Unpublished master's thesis, Indiana State University, Terra Haute, Indiana.

Hilsendager, D. R., Strow, M. H., & Ackerman, K. J. (1969). Comparison of speed, strength, and agility in the development of agility. Research Quarterly, 40, 71-75.

Houston, M. E., & Goemans, P. H. (1981). Leg Muscle Performance of Athletes With and Without Knee Support Braces. Archives of Physcial Medicine and Rehabilitation, 63, 431-432.

Isolated Joint Testing and Exercise: A Handbook for Using Cybex II and UBXT. (1983). Bayshore, NY: Cybex.

Johnson, A. (1969). _The Effects Of Wearing A Knee Guard On Agility_. Unpublished master's thesis, Indiana State University, Terra Haute, Indiana.

Johnson, J., & Siegel, D. (1978). Reliability of an Isokinetic Movement of the Knee Extensors. _Research Quarterly_, 49, 88-90.

Kirby, R. (1971). A simple Measure of Agility. Coach & Athlete, 30-31.

Klafs, C. E., & Arnheim, D. D. (1981). _Modern Priniples of Athletic Training_ (5th ed.). St. Louis: C. V. Mosby.

May, T. L. (1971). _Effect Of The Arco Knee Guard Upon Agility Determined By The Forty Yard Maze Test_. Unpublished master's thesis, Indiana State University, Terra Haute, Indiana.

Martindale, A. (1973). _Effect Of The Arco Knee Guard On Agility_. Unpublished master's thesis, Indiana State University, Terra Haute, Indiana.

Mawdsley, R. H., & Knapik, J. J. (1982). Effects of Submaximal Contractions Before Isokinetic Testing. _The Journal of the National Athletic Trainers Association_, _17_, 249-252.

McCloy, C. H., & Young, N. D. (1954). _Tests and Measurements in Health and Physical Education_. New York: Apleton-Century-Crofts.

McDavid Knee Guard Inc. (1985). McDavid Knee Guard. Clarendon Hills, Illinois.

McNorris, R. O., & Elkins, E. C. (1954). A study of production an evaluation of muscular hypertrophy. _Archives of Physical Medicine_, _35_, 420-426.

Mihoces, G., (1985, January 11). Knee injuries stagger some of NFL's best. _USA Today_, p.1.

Mohr, D. R., & Haverstick, M. J. (1956). Relationship Between Height, Jumping Ability and Agility to Volleyball Skill. _Research Quarterly_, 27, 74.

Nwaobi, O. M. (1980). Effect of Bracing, Elastic Taping and Non-Elastic Taping on Medial Stability of the knee. _Medicine and Science in Sports and Exercise_, _12_, 137.

Omni Scientific Inc. (1984). Anderson Knee Stabler. Lafayette, California.

Pipes, T., & Wilmore, J. (1975) Isokinetic vs isotonic strength training in adult men. Medicine and Science in Sports, 7, 262-274.

Powell, J. W. (1985). Pattern of Knee Injuries Associated with College Football 1975-1982. The Journal of the National Atheltic Trainers Association, 20, 104-109.

Pritchett, J. W. (1982). A Statistical Study of Knee Injuries due to Football in High-School Athletes. The Journal of Bone and Joint Surgery, 2, 240-242.

Richards, J. G., & Cooper, J. (1982). Implementation of on-line isokinetic analysis system. Journal of Orthopaedic and Sports Medicine, 4, 36-38.

Rockwell, J. (1979). Scanning Sports. The Physician and Sportsmedicine, 7, 12.

Statistical Analysis System, (1982). Virginia Polytechnic Institute & State University, Blacksburg, Virginia.

Tedeschi, A. J. (1984). The Effect Of The Anderson Knee Stabler On Various Components Of Knee Function. Unpublished master's thesis, University of the Pacific, Stockton, California.

Townsend, M. A., Izak, M., & Jackson, R. W. (1977). Total Motion Knee Goniometry. Journal of Biomechanics, 10, 183-193.

Wyatt, M. P., Edwards, & Anna, M. (1981). Comparison of Quadriceps and Hamstring Torque Values During Isokinetic Exercise. The Journal of Orthopaedic and Sports Physical Therapy, 3, 48-56.

APPENDIX A

DETAILED METHODOLOGY

METHODOLOGY

Selection of Subjects

Thirty-two male Virginia Tech varsity football players volunteered to participate in this investigation. The following criteria was used for the selection of the subjects:

1. The subjects must have worn a protective knee brace during the football season.

2. The subjects must not be currently participating in a current weight training program for the hips, low back, or legs.

3. The subjects must not have any predisposing orthopedic condition of the knee, hip, low back, or ankle (eg. prior corrective surgery or extreme laxity of the ligaments or tendons surrounding the knee, hip, or ankle joint).

4. The subjects must have completed and passed a subject screening evaluation. The screening form is found in Appendix B.

5. This investigation was approved by the Department of Physical Education Human Subjects Committee at Virginia Tech. Each participant read and

signed the informed consent form prior to their participation in this study. The informed consent form is found in Appendix C.

Football players representing different team positions participated in this investigation. A position summary is displayed in Appendix D.

Experimental Procedure

Agility Tests:

Each subject signed an informed consent form and completed the medical screening prior to being administered the Semo agility test.

All subjects were given the agility familiarization drill. The protocol for the familiarization drill and test are displayed in Appendix E.

The Semo agility test was used in this investigation to measure a change of direction. The movement patterns required to complete the agility test were the cross-over step, back pedaling, and forward sprinting. Since the subjects were football players, the investigator substituted the cross-over step for the side step. The cross-over step is especially important for pulling guards and running backs. Investigators have determined that when a lateral movement in which maximum speed is needed, as in football, the cross-over step may be the technique to use. (Chandler, Langley, & Blair, 1967)

Prior to the beginning of the agility test, each subject had been randomly placed into one of the three experimental conditions for each testing session. These conditions consisted of having the subject either wear the Anderson knee stabler on both knees during the agility testing, wear the Arco knee guard on both knees during the agility testing, or not wear any protective knee brace during the agility testing (unbraced). The Anderson knee stabler worn during the entire study was model number 101W, and was manufactured by Omni Scientific Inc. (Omni Scientific, Inc. 1984) The Arco knee guard utilized in the study was model number M102, and was manufactured by McDavid. (McDavid, 1985) All protective knee braces used in this investigation were new and had never been worn prior to testing.

The Semo agility test was performed in an indoor astroturf facility. Cones were used to mark the agility course. Once the subjects had reported to the testing site, they were informed as to which experimental condition they were assigned. Each brace was placed on the subjects by the investigator according to the proper procedure recomended by the manufacturer. (Omni Scientific Inc., 1984, & McDavid Knee Guard Inc., 1985) All subjects were required to perform the agility test in either turf shoes or tennis shoes. Each subject was timed in the agility test and the scores were recorded to the nearest hundredth of a second.

Cybex Testing:

Each subject was administered a Cybex familiarization test session on the Cybex II Isokinetic machine. To initiate the Cybex familiarization procedure, the subject was positioned in the Cybex testing apparatus. The Cybex dynamometer was aligned and positioned by the investigator according to the recommended procedure by Cybex. (Cybex, 1984) The subject's set-up position variables were recorded and used throughout all Cybex testing sessions. With the hip positioned in 90 degrees of flexion, the subjects were instructed to perform knee extension and knee flexion exercises using the preferred leg. The Cybex familiarization and test protocol for knee extension and knee flexion are found in Appendix F.

Once the subject was positioned properly, he was secured in the testing position by the use of velcro stabilization straps. The stabilization straps included the upper torso strap, the pelvic strap, and the thigh strap. These stabilization straps secured the subject and helped eliminate muscle substitution. The subjects were instructed to keep their arms crossed during the test. A towel was placed between the thigh stabilization strap and the subjects quadricep to keep the velcro strap from irritating the subject's leg during the isokinetic tests.

The subjects were randomly assigned to one of three experimental conditions. If the subjects testing condition for that particular day required a protective knee brace, the investigator positioned the brace on the subjects preferred leg. All warm-up trials allowed prior to testing were performed in the assigned testing condition.

The most common recommended isokinetic test speed to measure strength is 60 degrees per second. (Cybex, 1984) This speed was selected as the slow test speed for this investigation.

Velocities at the knee joint during running usually occur between 400 degrees per second and 1200 degrees per second (Davies, 1984), and most medial collateral ligament injuries in football occur when the angular motion of the knee joint is 320 degrees per second (Rockwell, 1979) therefore, the investigator selected 300 degrees per second joint angle velocity as the fast Cybex testing speed. Three hundred degrees per second is the highest rate of speed possible with the Cybex system.

Each subject's leg was weighed during the Cybex tests and all data were gravity corrected. A variation of plus or minus one ft-lb was considered normal and was used as the criterion measure for gravity effect torque (Get). (Cybex, 1983)

The encouragement provided by the investigator during Cybex testing was standardized by using predetermined statements of verbal encouragement.

For the 60 degrees per second knee joint angle velocity test, the Cybex data reduction computer calculated the measurements of peak torque/body weight ratio of the quadriceps and hamstring musculature, and the range of motion of the knee joint during extension and flexion.

Measurements calculated during the 300 degrees per second test included: peak torque/body weight ratio for the quadriceps and hamstrings, average range of motion of the knee joint during extension and flexion, torque acceleration energy of the quadriceps and hamstrings, average power of the quadriceps and hamstrings, and endurance of the quadriceps and hamstrings.

When testing athletes such as college football players, an endurance test that requires 40 repetitions of knee extension and flexion is recommended. (Cybex, 1983) Of these 40 repetitons, a sample size of 20% of the total repetitions performed was used. The Cybex data reduction computer was programmed to sample the total work during the first eight repetitions during the endurance test, and compared them to the total work of the last eight repetitions of the endurance test. The percent difference was recorded as the endurance ratio. (Cybex, 1983)

Torque was measured across three trials in the 60 degrees per second Cybex test, and across five repetitions in the 300 degrees per second Cybex test. Torque was recorded in Ft-lbs and range of motion in degrees. Maximum values were selected as the subjects criterion score for the variables of peak torque/body weight ratio and torque acceleration energy. Average power (watts) was recorded as the total work divided by the time required to perform this work.

The subjects endurance ratio was recorded as the percent change in total work from the first 8 repetitions to the last 8 repetitions in a 40 repetition test.

Statistical Results

Semo Agility Test:

Each subject was administered three trials under each experimental condition (repeated measures). The order of testing was randomized. The Statistical Analysis System (SAS, 1982) was used to analyze the experimental test data.

A two-way repeated measures ANOVA was conducted on the three trial scores from each experimental condition to determine whether significant differences existed between trials. A significant between trial difference was found at the .05 level. Therefore, the best score was selected as the criterion score for each subject in each experimental condition. Table 1. provides the descriptive statistics for the agility test administered under the three experimental conditions.

Repeated measures analysis of variance was used to calculate intraclass reliability for the scores from the agility testing. (Ary, Jacobs, & Razavieh, 1979) Table 2. provides the intraclass reliability estimates for the three experimental conditions. Each of the three experimental conditions produced reliability estimates greater than R = .90.

A one-way analysis of variance was used to test the hypothesis of no difference in agility across the three experimental conditions. The ANOVA results appear in Table 3. and indicate no significant difference was found between the subjects as they performed the agility test in the unbraced condition or the braced Arco or braced Anderson condition.

Peak Torque/Body Weight Ratio:

ANOVA was used to test the hypothesis of no difference in peak torque to body weight ratio of knee extension at 60 degrees per second joint angle velocity across the three experimental conditions. The ANOVA results appear in Table 4. and demonstrate that no

Table 1.

Descriptive Statistics for the Semo Agility Test

Conditions	Mean (sec)	SD	STD Error
Arco	11.40	.374	.066
Anderson	11.37	.397	.070
Unbraced	11.30	.385	.068

Table 2.

Intraclass Reliability Estimates of the Three Experimental Conditions for the Semo Agility Test

(n = 32)

Arco Condition	R = .92
Anderson Condition	R = .91
Unbraced Condition	R = .92

Table 3.

Analysis of Variance Source Table for Agility

Source	DF	SS	MS	F - Value	P > F
Conditions	2	.1608	.0804	.58	.585
Error	93	13.8627	.1490		
Total	95	14.0235			

Table 4.

ANOVA for Peak Torque/Body Weight Ratio for

Knee Extension at 60 Degrees Per Second

Source	DF	SS	MS	F - Value	P > F
Condition	2	336.27	168.14	.70	.498
Error	93	22267.47	239.44		
Total	95	22603.74			

significant difference was found between the experimental groups.

To test the hypothesis of no difference in peak torque to body weight ratio of knee flexion at 60 degrees per second joint angle velocity, the investigator utilized analysis of variance. The results appear in Table 5. and indicate no significant difference was found between the experimental conditions.

Peak torque to body weight ratio of knee extension and flexion were also statistically analyzed at speeds of 300 degrees per second joint angle velocity. The ANOVA results appear in Table 6. and 7. No significant difference was found in peak torque to body weight ratio in knee extension or flexion at speeds of 300 degress per second.

Torque Acceleration Energy:

ANOVA was employed by the investigator to test the hypothesis that no difference in torque acceleration energy of the knee extensors and knee flexors at 300 degrees per second joint angle velocity occurred between the three experimental conditions. The statistical results are found in Table 8. and 9. No significant

Table 5.

ANOVA for Peak Torque/Body Weight Ratio for Knee Flexion at 60 Degrees Per Second

Source	DF	SS	MS	F - Value	P > F
Condition	2	91.93	45.96	1.03	.36
Error	93	4142.71	44.55		
Total	95	4234.64			

Table 6.

ANOVA for Peak Torque/Body Weight Ratio for Knee Extensions at 300 Degrees Per Second

Source	DF	SS	MS	F - Value	P > F
Condition	2	3.06	1.53	.03	.97
Error	93	4898.34	52.67		
Total	95	4901.40			

Table 7.

ANOVA for Peak Torque/Body Weight Ratio for Knee Flexion at 300 Degrees Per Second

Source	DF	SS	MS	F - Value	P > F
Condition	2	36.18	18.09	.48	.62
Error	93	3515.21	37.99		
Total	95	3551.39			

Table 8.

ANOVA for TAE in Knee Extension at 300 Deg/Sec

Source	DF	SS	MS	F - Value	P > F
Condition	2	40.78	30.39	.41	.66
Error	93	4597.01	49.43		
Total	95	4637.79			

Table 9.

ANOVA for TAE in Knee Flexion at 300 Deg/Sec

Source	DF	SS	MS	F - Value	P > F
Condition	2	41.39	20.69	.89	.41
Error	93	2171.26	23.34		
Total	95	2212.65			

difference in torque acceleration energy of the knee extensors and flexors were noted across the three conditions.

Average Power:

Average power of the knee extensors and flexors was also measured at the speed of 300 degrees per second within each experimental condition. ANOVA was used to determine if there was a significant difference between the three conditions. Tables 10. and 11. display the statistical analysis. No significant difference was found in either knee extension or flexion between the three experimental conditions.

Average Range of Motion:

ANOVA was used to test the hypothesis that no difference in average range of motion in knee extension and flexion at 60 and 300 degrees per second joint angle velocity occurred between the three experimental conditions. The statistical results are displayed in Table 12. - 15. No significant difference was found in the average range of the knee extensors or flexors across the three experimental conditions.

Table 10.

ANOVA for Average Power in Knee Extension at 300 Deg/Sec

Source	DF	SS	MS	F - Value	P > F
Condition	2	989.43	494.71	.19	.83
Error	93	24224.18	2647.57		
Total	95	247213.61			

Table 11.

ANOVA for Average Power in Knee Flexion at 300 Deg/Sec

Source	DF	SS	MS	F - Value	P > F
Source	2	3681.27	1840.63	1.35	.26
Error	93	6714.06	1362.51		
Total	95	130395.33			

Table 12.

ANOVA for Average Range of Motion for Knee Extension at 300 Deg/Sec

Source	DF	SS	MS	F - Value	P > F
Condition	2	60.81	30.40	.66	.52
Error	93	4311.81	46.36		
Total	95	4372.62			

Table 13.

ANOVA for Average Range of Motion for Knee Flexion at 300 Deg/Sec

Source	DF	SS	MS	F - Value	P > F
Condition	2	58.52	29.26	.62	.54
Error	93	4385.21	47.15		
Total	95	4443.73			

Table 14.

ANOVA for Average Range of Motion for Knee Extension at 60 Deg/Sec

Source	DF	SS	MS	F - Value	P > F
Condition	2	27.14	30.40	.33	.72
Error	93	3869.81			
Total	95	3886.95			

Table 15.

ANOVA for Average Range of Motion for Knee flexion at 60 Deg/Sec

Source	DF	SS	MS	F - Value	P > F
Condition	2	15.89	43.84	.18	.83
Error	93	4149.09			
Total	95	4164.98			

Endurance Ratio:

The endurance ratio of the knee extensors and flexors at 300 degrees per second were compared under the three experimental conditions. ANOVA results appear in Table 16. and 17. No significant difference was found in either knee extension or flexion between the Arco, Anderson, and Unbraced condition.

Summary

The subjects were administered the Semo agility test under three experimental conditions: 1) wearing the Arco knee guard 2) wearing the Anderson knee stabler or 3) in an unbraced condition. The statistical analysis revealed no significant differences in the agility test scores between the three experimental conditions.

The subjects were also administered a standard Cybex knee extension/flexion test at speeds of 60 degrees per second and 300 degrees per second under the three experimental conditions. The Cybex measures recorded at the test speed of 60 deg/sec included: peak torque/body weight ratio and average range of motion. No statistical difference was found between the three test conditions for either peak torque/body weight ratio

Table 16.

ANOVA for Endurance Ratio of Knee Extension at 300 Deg/Sec

Source	DF	SS	MS	F - Value	P > F
Condition	2	27.58	13.79	.17	.84
Error	93	7580.15	81.50		
Total	95	7607.73			

Table 17.

ANOVA for Endurance Ratio of Knee Flexion at 300 Deg/Sec

Source	DF	SS	MS	F - Value	P > F
Condition	2	30.33	15.16	.10	.90
Error	93	13793.00	148.31		
Total	95	13823.33			

or average range of motion. Table 18. and 19. shows the mean comparisons for each variable measured under each of the experimental conditions.

The variables recorded at 300 degrees per second joint angle velocity included: peak torque/body weight ratio, torque acceleration energy, average power, average range of motion, and endurance ratio. No statistical difference was found between the three experimental conditions for any of the muscular function variables during either knee extension or knee flexion. Tables 20. - 24. display the mean comparison of each variable recorded within each test condition.

Table 18.

Mean Peak Torque/Body Weight Ratio of Knee Extension and Flexion at 60 Deg/Sec

	Extension		Flexion	
Condition	(N)	Mean (Ft-lbs)	(N)	Mean (Ft-lbs)
Arco	32	93.09	32	54.06
Anderson	32	89.18	32	54.96
Unbraced	32	89.06	32	56.43

Table 19.

Mean Average Range of Motion of Knee Extension and Flexion at 60 Deg/Sec

	Extension		Flexion	
Conditon	(N)	Mean (Deg)	(N)	Mean (Deg)
Arco	32	169.85	32	117.88
Anderson	32	168.57	32	116.91
Unbraced	32	169.41	32	117.19

Table 20.

Mean Peak Torque/Body Weight Ratios of Knee Extension and Knee Flexion at 300 Deg/Sec

	Extension		Flexion	
Condition	(N)	Mean (Ft-lbs)	(N)	Mean (Ft-lbs)
Arco	32	48.50	32	33.78
Anderson	32	48.71	32	32.98
Unbraced	32	48.93	32	34.43

Table 21.

Mean Torque Acceleration Energy of Knee Extension and Flexion at 300 Deg/Sec

	Extension		Flexion	
Condition	(N)	Mean (Ft-lbs)	(N)	Mean (Ft-lbs)
Arco	32	44.97	32	27.43
Anderson	32	45.30	32	28.19
Unbraced	32	46.49	32	29.04

Table 22.

Mean Average Power of Knee Extension and Flexion at 300 Deg/Sec

	Extension		Flexion	
Condition	(N)	Mean (Watts)	(N)	Mean (Watts)
Arco	32	306.22	32	166.31
Anderson	32	301.34	32	167.28
Unbraced	32	309.13	32	179.91

Table 23.

Mean Average Range of Motion for Knee Extension and Flexion at 300 Deg/Sec

	Extension		Flexion	
Condition	(N)	Mean (Deg)	(N)	Mean (Deg)
Arco	32	119.28	32	120.00
Anderson	32	119.22	32	120.00
Unbraced	32	117.56	32	118.34

Table 24.

Mean Endurance Ratio for Knee Extension and Flexion at 300 Deg/Sec

	Extension		Flexion	
Condition	(N)	Mean (Percent)	(N)	Mean (Percent)
Arco	32	.52	32	.36
Anderson	32	.51	32	.35
Unbraced	32	.50	32	.36

APPENDIX B

SUBJECT SCREENING FORM

SCREENING FORM

Name: ______________________________

Preferred Leg: ____________________

History

1) Has any surgery been performed on any of the following areas? Please answer yes or no.

   a) ankle _____
   b) knee _____
   c) hip _____
   d) low back or abdomin _____

2) Do you at the present time experience any pain or have any limitations in any of the following areas? Please answer yes or no.

   a) ankle _____
   b) knee _____
   c) hip _____
   d) low back or abdomin _____

   If you answered yes to any of the above, please explain below.

If yes is answered to any of the above questions a range of motion and joint laxity evaluation will be performed.

RANGE OF MOTION EVALUATION

1) Ankle

	Findings
a) active dorsi flexion	________
b) active plantar flexion	________
c) active inversion	________
d) active eversion	________
e) passive dorsi flexion	________
f) passive plantar flexion	________
g) passive inversion	________
h) passive eversion	________

2) Knee

a) active knee flexion	________
b) active knee extension	________
c) passive knee flexion	________
d) passive knee extension	________

3) Hip

a) active hip flexion	________
b) active hip extension	________
c) active hip abduction	________
d) active hip adduction	________
e) active hip internal rotation	________
f) active hip external rotation	________
g) passive hip flexion	________
h) passive hip extension	________
i) passive hip abduction	________
j) passive hip adduction	________
k) passive hip internal rotation	________
l) passive hip external rotation	________

4) Trunk

a) active trunk flexion	________
b) active trunk extension	________

JOINT LAXITY EVALUTATION

1) Ankle

a) anterior drawer stress test _______
b) side-to-side stress test _______
c) inversion stress test _______
d) everison stress test _______

2) Knee

a) valgus stress in full knee extension _______
b) arus stress in full knee extension _______
c) valgus stress in 30 deg of knee flexion _______
d) varus stress in 30 deg of knee flexion _______
e) Lockman's test _______
f) Apley's compression test _______
g) McMurray's test _______
h) Apley's distractions

3) Hip, lumbar spine

a) Patrick test _______
b) Pelvic rock test _______
c) Gaenslen's sign _______
d) Straight leg raise test _______

INSPECTION

Each subject will be visually inspected for any ovious deformities, swelling, and abnormal gait.

APPENDIX C

INFORMED CONSENT

HUMAN PERFORMANCE LABORATORY

Division of Health, Physical Education
and Recreation
Virginia Polytechnic Institute and State University

INFORMED CONSENT

I, ____________________________________, do hereby voluntarily agree and consent to participate in a testing program conducted by the personnel of the Human Performance Laboratory of the Division of Health, Physical Education and Recreation of Virginia Polytechnic Institute and State University.

Title of Study:

The effect of protective knee braces on agility and muscle performance.

Purpose of this experiment include:

To measure isokinetic peak torque/body weight ratio of the quadriceps and hamstrings of the subjects preferred leg, knee range of motion, torque acceleration energy of the quadriceps and hamstrings, average power of the quadriceps and hamstrings, and the endurance ratio of the quadricep and hamstring musculature. To also measure agility performance using the Semo agility test.

I voluntarily agree to participate in this testing program. It is my understanding that my participation will include:

1) Cybex isokinetic knee extension/flexion strength and endurance testing under three experimental conditions:

    a) knee stabilized with the Anderson knee stabler
    b) knee stabilized with the Arco knee guard
    c) knee not stabilized

2) Isokinetic tests speeds of 60 deg/sec @ 3 repetitions, and 300 deg/sec @ 40 repetitions.

3) Isokinetic testing of the preferred leg.

4) Agility tests include:
   a) both knees stabilized with the Anderson knee stabler
   b) both knees stabilized with the Arco knee guard
   c) both knees not stabilized

I understand that participation in this experiment may produce certain discomforts and risks. These discomforts and risks include:

1) Possible muscular fatigue.
2) Possible muscular strain.
3) Local delayed muscle soreness.
4) Elevated systolic blood pressure.

Certain personal benefits may be expected from participation in this experiment. These include:

1) Diagnostic evaluation of the knee extensors and flexors. 2) Opposing muscle group ratios will be calculated.

Appropriate alternative procedures that might be advantageous to you include:

None

I understand that any data of a personal nature will be held confidential and will be used for research purpose only. I also understand that these data may only be used when not identifiable with me.

I understand that I may abstain from participation in any part of the experiment or withdraw from the experiment should I feel the activities might be injurious to my health. The experimenter may also terminate my participation should he feel the activities might be injurious to my health.

I understand that it is my personal responsibility to advise the researchers on any preexisting medical problems that may affect my participation or of any medical problems that might arise in the course of this experiment and that no medical treatment or compensation is available if injury is suffered as a result of this research. A telephone is available which would be used to call the local hospital for emergency service.

I have read the above statements and have had the opportunity to ask questions. I understand that the researchers will, at any time, answer my inquiries concerning the procedures used in this experiment.

Scientific inquiry is indispensable to the advancement of knowledge. Your participation in this experiment provides the investigator the opportunity to conduct meaningful scientific observations designed to make significant educational contributions.

If you would like to receive the results of this investigation, please indicate this choice by marking in the appropriate space provided below. A copy will then be distributed to you as soon as the results are made available by the investigator. Thank you for making this important contribution.

________ I request a copy of the results of this study.

Date __________ Time _____ a.m./p.m.

Participant Signature ____________________________

Witness ____
HPL Personnel

Project Director _______________ Telephone _______________

HPER Human Subjects Chairman Dr. Don Sebolt

Telephone _____________________

Dr. Charles Waring, Chairman, Institutional Review Board for Research Involving Human Subjects. Phone 961-5283

APPENDIX D

SUBJECT POSITION SUMMARY

VARSITY PLAYER POSITION

Position	Number of Subjects
Offense	
Guard	4
Tackle	5
Center	3
Tight End	1
Quarterback	1
Total Offensive Players	14
Defense	
Tackle	4
Nose Guard	2
Line Backer	3
End	6
Back	3
Total Defensive Players	18
Total Players	32

APPENDIX E

AGILITY TEST

AGILITY FAMILIARIZATION PROTOCOL

---

1. Subjects were instructed on how to run the Semo agility drill and were given a demonstration by the investigator.

2. Each subject was then instructed to jog through the Semo agility drill pattern.

3. Each subject was then instructed to perform the required flexibility exercises and was allowed additional warm-up time if needed. The flexibility exercises included: stretching the gastroc, hamstrings, quadriceps, hip flexors, hip adductors, and the low back.

4. Each subject was then required to perform five trials of the agility test. Three trials were submaximal trials while the last two were maximal trials.

AGILITY TESTING PROTOCOL

---

1. Each subject was testing in only one experimental condition per day.

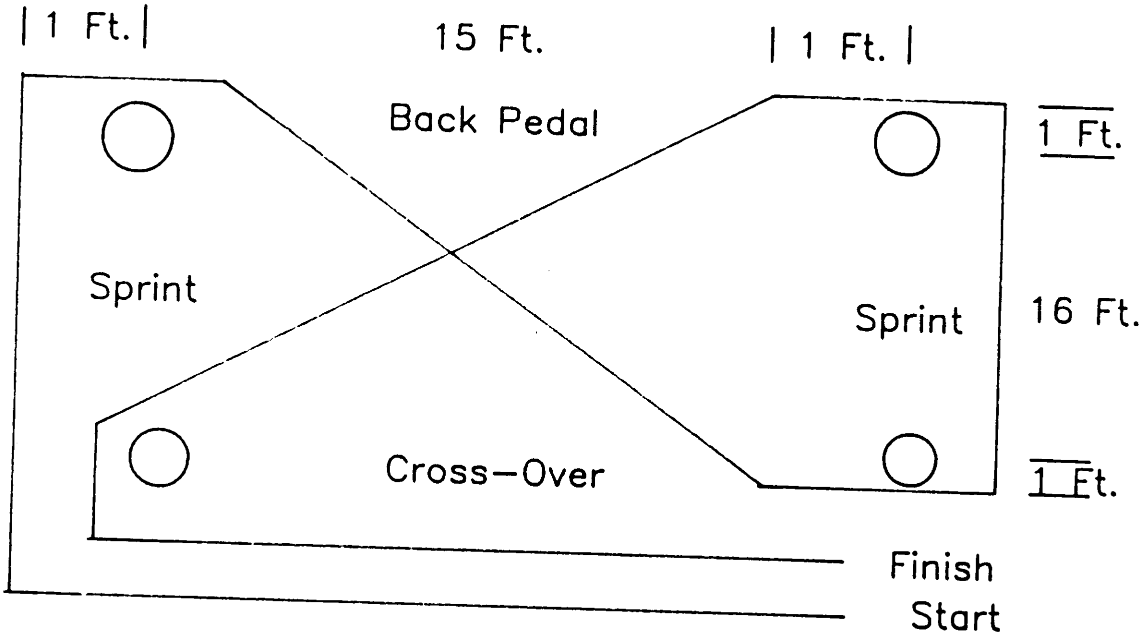
2. The subjects were instructed to jog through the agility drill.

3. The subjects were instructed to perform the required flexibility exercises and were allowed additional warm-up if needed.

4. The subject proceeded to run through the agility test in the testing condition twice, the first practice trial was a submaximal trial, while the second trial was a maximal trial.

5. After the practice trials had been completed, the subjects performed three maximal trials of the agility test with a rest period of three minutes between trials.

6. Each trial time recording began when the subject moved from his starting position, and ended when the subject crossed the last cone of the agility course. The starting position required the subject to place his left foot in the center of the starting cone, and then proceed to move in a lateral direction to the left using cross-over steps, and continue through the agility test.



Semo Agility Test

APPENDIX F

CYBEX TEST

CYBEX KNEE EXTENSION/FLEXION TEST

STABILIZATION FORM

Name: ______________________________________

Date: ______________________________________

Preferred leg: ____________________________

Height of dynamometer: __________________

Length of dynamometer: __________________

Number of back pads: ____________________

Ship pad position (No. of holes): ________

Stabilization straps used: ______________

TESTING CONDITIONS

Testing Session 1: ____________________

Testing Session 2: ____________________

Testing Session 3: ____________________

CYBEX TEST PROTOCOL FOR KNEE EXTENSION/FLEXION

---

60 Degree/second Joint Angle Velocity

30 Second general warm-up
3 Submaximal trials
3 Maximal trials
3 Maximal test trials

300 Degree/second Joint Angle Velocity

30 Second general warm-up
5 Submaximal trials
4 Maximal trials
40 Maximal test trials

TEST INSTRUCTIONS FOR ISOKINETIC TESTING AT 60 AND 300 DEGREES PER SECOND JOINT ANGLE VELOCITY

INSTRUCTIONS PRIOR TO TESTING

Statement 1: "This test requires that you provide maximal effort on every repetition."

Statement 2: "You will complete three maximal repetitions for the 60 degrees per second test and 40 for the 300 degrees per second test. The computer will count for your repetitions. You must continue until I inform you to stop."

ENCOURAGEMENT DURING TESTING

Statement 1: "Ready? Start when you are ready, and remember to make every repetition as hard and as fast as you can."

Statement 2: "Hard as you can, keep going, hard as you can, keep going, don't stop, hard as you can, keep going, hard as you can, keep going, don't stop etc."

APPENDIX G

RAW DATA

Legend

AND	=	Trial condition using the Anderson knee stabler
ARCO	=	Trial condition using the Arco knee guard
UN	=	Trial condition using no brace
PTQ	=	Peak torque of the quadriceps
PTQ/BW	=	Peak torque/body weight ratio of the quadriceps
PTH	=	Peak torque of the hamstrings
PTH/BW	=	Peak torque/body weight ratio of the hamstrings
BW	=	Body weight
AVROM	=	Average range of motion
TAEQ	=	Torque acceleration energy of the quadriceps
TAEH	=	Torque acceleration energy of the hamstrings
AVPQ	=	Average power of the quadriceps
AVPH	=	Average power of the hamstrings
ENDQ	=	Endurance ratio of the quadriceps
ENDH	=	Endurance ratio of the hamstrings
COND	=	Testing condition
SUB	=	Subject

RAW DATA: SEMO AGILITY TEST

SUB	BW	TRIAL	AND	ARCO	UN
1	240	1	12.89	12.18	11.39
		2	12.35	11.97	11.83
		3	12.11	11.96	11.80
2	250	1	11.40	11.23	11.90
		2	11.22	11.36	11.10
		3	11.40	11.35	11.11
3	260	1	11.74	11.23	11.90
		2	11.52	11.92	11.39
		3	12.09	11.39	11.52
4	255	1	11.88	11.76	12.26
		2	15.59	11.63	17.79
		3	12.01	11.78	11.77
5	265	1	11.69	12.49	11.72
		2	11.52	11.74	11.72
		3	11.17	11.78	11.39
6	255	1	11.39	11.72	11.74
		2	11.46	11.37	11.39
		3	11.64	11.25	11.47

SEMO AGILITY TEST CONT.

SUB	BW	TRIAL	AND	ARCO	UN
7	220	1	11.67	11.79	11.74
		2	11.37	11.57	11.45
		3	11.48	11.45	11.91
8	213	1	11.19	11.07	11.05
		2	11.14	11.18	11.00
		3	10.74	11.19	10.88
9	260	1	11.45	11.39	11.49
		2	11.13	11.40	11.31
		3	11.11	11.42	11.21
10	240	1	11.49	11.20	11.20
		2	11.24	10.93	10.92
		3	10.93	10.56	10.71
11	265	1	11.77	11.94	12.25
		2	11.76	11.72	11.98
		3	11.91	11.85	11.71
12	235	1	12.53	12.38	12.12
		2	11.93	12.33	11.99
		3	12.24	11.77	12.07
13	235	1	11.36	11.70	11.47
		2	11.35	11.67	11.47
		3	11.95	11.76	11.01

SEMO AGILITY TEST CONT.

SUB	BW	TRAIL	AND	ARCO	UN
14	175	1	12.04	11.70	11.47
		2	11.71	11.81	11.62
		3	11.45	11.24	11.43
15	167	1	11.88	12.08	11.88
		2	12.05	11.82	11.65
		3	11.55	11.89	11.57
16	236	1	11.67	11.60	11.95
		2	11.75	11.67	11.80
		3	11.76	11.55	11.70
17	265	1	11.16	11.38	11.06
		2	11.31	11.06	11.23
		3	11.09	10.94	11.18
18	253	1	11.94	11.30	11.41
		2	11.44	11.56	11.32
		3	11.40	11.09	11.40
19	241	1	12.73	12.08	12.17
		2	12.12	11.85	11.97
		3	11.79	12.02	12.07
20	180	1	11.43	12.19	11.30
		2	11.37	11.82	11.26
		3	11.34	11.50	11.44

SEMO AGILITY TEST CONT.

SUB	BW	TRIAL	AND	ARCO	UN
21	207	1	11.49	11.70	11.67
		2	11.38	11.49	11.41
		3	11.01	11.62	11.61
22	212	1	11.20	11.20	11.21
		2	11.57	11.30	11.39
		3	10.85	11.06	10.88
23	212	1	11 84	11 57	11 95
		2	11.65	11.44	11.64
		3	11.57	11.54	11.52
24	202	1	10.65	11.08	10.73
		2	10.46	10.58	11.64
		3	11.57	10.87	10.65
25	225	1	11.28	11.47	11.56
		2	11.38	11.43	11.23
		3	11.11	11.67	11.44
26	265	1	11.75	11.56	10.74
		2	11.17	11.50	10.96
		3	10.96	11.45	10.83
27	226	1	11.29	11.80	11.08
		2	10.95	11.34	10.92
		3	10.98	11.13	10.95

SEMO AGILITY TEST CONT.

SUB	BW	TRIAL	AND	ARCO	UN
28	257	1	11.44	11.63	11.13
		2	11.61	11.81	11.13
		3	11.21	11.37	11.38
29	245	1	12.12	11.74	11.93
		2	12.29	11.87	11.81
		3	12.13	12.02	12.16
30	279	1	12.46	11.74	11.93
		2	11.92	11.87	11.81
		3	12.17	12.28	11.81
31	220	1	11.34	11.08	11.10
		2	11.26	10.94	11.09
		3	10.97	11.01	11.04
32	212	1	11.71	11.83	12.18
		2	11.98	11.50	11.79
		3	11.71	11.31	11.58

RAW DATA: CYBEX TESTING RESULTS FOR KNEE EXTENSION AND KNEE FLEXION AT 60 DEGREES PER SECOND JOINT ANGLE VELOCITY

SUB	BW	COND	PTQ	PTQ/BW	PTH	PTH/BW	AVROM
1	240	And	241	106	142	59	109
		Arco	178	74	112	47	
		Un	240	100	146	61	
2	250	And	272	109	149	60	112
		Arco	288	115	153	61	
		Un	290	116	142	57	
3	250	And	231	89	128	49	96
		Arco	223	86	136	52	
		Un	226	87	145	56	
4	255	And	199	78	124	49	122
		Arco	178	70	136	53	
		Un	195	76	132	52	
5	265	And	224	85	122	46	114
		Arco	210	79	115	43	
		Un	200	75	127	48	
6	255	And	238	93	132	52	125
		Arco	233	91	145	57	
		Un	207	81	143	56	

CYBEX TEST RESULTS AT 60 DEGREES PER SECOND CONT.

SUB	BW	COND	PTQ	PTQ/BW	PTH	PTH/BW	AVROM
7	220	And	296	135	147	67	120
		Arco	254	115	145	66	
		Un	276	125	151	69	
8	213	And	159	75	129	61	100
		Arco	188	88	145	68	
		Un	176	83	149	70	
9	260	And	187	72	120	46	116
		Arco	166	64	124	48	
		Un	132	51	131	50	
10	240	And	250	104	120	50	107
		Arco	238	99	129	54	
		Un	255	106	142	59	
11	265	And	228	86	143	54	106
		Arco	208	78	139	52	
		Un	225	85	148	56	
12	235	And	215	91	138	59	103
		Arco	195	83	128	54	
		Un	196	83	120	51	
13	235	And	240	102	112	48	102
		Arco	245	104	121	51	
		Un	266	113	132	56	

CYBEX TEST RESULTS AT 60 DEGREES PER SECOND CONT.

SUB	BW	CON	PTQ	PTQ/BW	PTH	PTH/BW	AVROM
14	175	And	179	102	99	57	105
		Arco	179	102	103	59	
		Un	174	99	102	58	
15	167	And	204	122	110	66	115
		Arco	207	124	99	59	
		Un	205	123	108	65	
16	236	And	195	83	109	46	110
		Arco	202	86	103	44	
		Un	189	80	95	40	
17	211	And	211	80	96	36	108
		Arco	223	84	108	41	
		Un	229	86	126	48	
18	253	And	215	85	139	55	111
		Arco	217	86	145	57	
		Un	205	81	127	50	
19	241	And	200	83	127	53	108
		Arco	174	72	130	54	
		Un	184	76	134	56	
20	180	And	204	113	115	64	112
		Arco	179	99	108	60	
		Un	197	109	111	62	

CYBEX RESULTS FROM 60 DEGREES PER SECOND CONT.

SUB	BW	COND	PTQ	PTQ/BW	PTH	PTH/BW	AVROM
21	207	And	204	99	107	52	102
		Arco	182	88	114	55	
		Un	140	68	127	61	
22	212	And	194	91	111	52	113
		Arco	205	96	117	55	
		Un	197	92	118	55	
23	212	And	197	90	117	54	101
		Arco	188	86	118	54	
		Un	164	75	125	57	
24	202	And	220	109	116	57	107
		Arco	226	112	113	56	
		Un	217	107	109	54	
25	225	And	164	81	132	59	94
		Arco	191	85	126	56	
		Un	188	84	130	58	
26	265	And	244	92	157	59	100
		Arco	221	83	116	44	
		Un	222	84	153	58	
27	226	And	126	56	89	39	100
		Arco	127	56	87	38	
		Un	131	58	106	47	

CYBEX RESULTS FROM 60 DEGREE PER SECOND CONT.

SUB	BW	COND	PTQ	PTQ/BW	PTH	PTH/BW	AVROM
28	257	And	247	96	136	53	104
		Arco	253	98	139	54	
		Un	290	113	153	60	
29	245	And	217	89	128	52	112
		Arco	202	82	115	47	
		Un	167	68	124	51	
30	279	And	204	73	107	38	118
		Arco	211	76	122	44	
		Un	176	63	95	34	
31	220	And	219	10	161	73	116
		Arco	206	94	149	68	
		Un	186	85	137	62	
32	212	And	150	71	111	52	99
		Arco	139	66	109	51	
		Un	139	66	122	58	

RAW DATA: CYBEX TESTING RESULTS FOR KNEE EXTENSION AND KNEE FLEXION AT 300 DEGREES PER SECOND JOINT ANGLE VELOCITY

SUB	BW	COND	PTQ	PTQ/BW	PTH	PTH/BW
1	240	AND	127	53	69	29
		ARCO	110	46	55	23
		UN	132	55	74	31
2	250	AN	130	52	79	32
		ARCO	145	58	87	35
		UN	146	58	81	32
3	250	AND	106	41	65	25
		ARCO	100	38	83	32
		UN	98	38	65	25
4	255	AND	123	48	80	31
		ARCO	118	46	74	29
		UN	121	47	89	35
5	265	AND	132	50	76	29
		ARCO	130	49	70	26
		UN	112	42	61	23
6	265	AND	113	44	84	33
		ARCO	124	49	85	33
		UN	140	55	93	36

CYBEX TESTS RESULTS AT 300 DEGREES PER SECOND CONT.

SUB	BW	COND	PTQ	PTQ/BW	PTH	PTH/BW
7	220	AND	152	69	101	46
		ARCO	144	65	100	45
		UN	147	67	106	48
8	213	AND	95	45	82	38
		ARCO	118	55	92	43
		UN	109	51	82	38
9	260	AND	98	38	60	23
		ARCO	82	32	60	23
		UN	59	23	63	24
10	240	AND	118	49	82	34
		ARCO	107	45	88	37
		UN	135	56	89	41
11	265	AND	121	46	79	30
		ARCO	123	46	80	30
		UN	126	48	93	35
12	235	AND	116	49	80	34
		ARCO	126	54	80	34
		UN	114	49	80	34
13	235	AND	119	51	79	34
		ARCO	116	49	88	37
		UN	127	54	76	32

CYBEX TESTS RESULTS AT 300 DEGREES PER SECOND CONT.

SUB	BW	COND	PTQ	PTQ/BW	PTH	PTH/BW
14	175	AND	94	54	68	39
		ARCO	97	55	68	39
		UN	94	54	63	36
15	167	AND	86	51	69	41
		ARCO	83	50	66	40
		UN	95	57	81	49
16	236	AND	95	40	41	17
		ARCO	92	39	52	22
		UN	89	38	38	16
17	265	AND	132	50	100	38
		ARCO	131	49	84	35
		UN	115	43	90	34
18	253	AND	105	42	80	32
		ARCO	112	44	91	36
		UN	112	44	81	32
19	241	AND	112	46	79	33
		ARCO	107	44	77	32
		UN	114	47	87	36
20	180	AND	92	51	61	34
		ARCO	85	47	65	36
		UN	86	53	62	34

CYBEX TESTS RESULTS AT 300 DEGREES PER SECOND CONT.

SUB	BW	COND	PTQ	PTQ/BW	PTH	PTH/BW
21	207	AND	104	50	51	25
		ARCO	100	48	64	31
		UN	95	46	73	35
22	212	AND	93	44	64	30
		ARCO	93	44	71	33
		UN	106	50	75	35
23	212	AND	101	46	61	28
		ARCO	116	53	80	37
		UN	112	51	74	34
24	202	AND	109	54	80	40
		ARCO	129	64	79	39
		UN	121	60	82	42
25	225	AND	110	49	74	33
		ARCO	103	46	73	32
		UN	109	48	74	33
26	265	AND	153	58	105	40
		ARCO	121	46	84	35
		UN	128	48	93	35
27	226	AND	68	30	26	12
		ARCO	91	40	71	31
		UN	76	34	67	30

CYBEX TESTS RESULTS AT 300 DEGREES PER SECOND CONT.

SUB	BW	COND	PTQ	PTQ/BW	PTH	PTH/BW
28	257	AND	104	40	82	32
		ARCO	109	42	78	30
		UN	120	47	91	35
29	245	AND	113	46	83	34
		ARCO	123	50	68	28
		UN	120	47	71	29
30	279	AND	127	46	75	27
		ARCO	165	59	89	32
		UN	140	50	83	30
31	220	AND	129	59	93	42
		ARCO	135	61	102	46
		UN	134	61	100	45
32	212	AND	92	43	61	29
		ARCO	96	45	73	34
		UN	83	39	80	38

RAW DATA: CYBEX TESTING RESULTS FOR KNEE EXTENSION AND KNEE FLEXION AT 300 DEGREES PER SECOND JOINT ANGLE VELOCITY

SUB	BW	COND	AVROM	TAEQ	TAEH
1	240	AND	123	45.19	23.06
		ARCO	125	37.12	39.43
		UN	117	51.84	26.65
2	250	AND	118	52.03	34.45
		ARCO	123	57.92	29.23
		UN	118	55.68	38.29
3	250	AND	109	44.75	36.47
		ARCO	112	44.04	32.61
		UN	111	47.58	32.45
4	255	AND	126	41.07	31.42
		ARCO	124	36.78	23.26
		UN	128	45.38	34.81
5	265	AND	125	51.07	28.11
		ARCO	124	51.21	27.56
		UN	122	43.89	23.04
6	255	AND	130	44.95	23.11
		ARCO	128	51.66	30.68
		UN	131	48.24	30.88

CYBEX RESULTS AT 300 DEGREES PER SECOND CONT.

SUB	BW	COND	AVROM	TAEQ	TAEH
7	220	AND	122	61.05	35.66
		ARCO	120	55.38	34.98
		UN	124	57.49	36.99
8	213	AND	109	48.18	26.09
		ARCO	117	50.36	31.25
		UN	118	42.33	25.07
9	260	AND	127	38.27	24.64
		ARCO	112	37.88	23.47
		UN	111	32.69	25.42
10	240	AND	128	51.36	28.11
		ARCO	122	49.19	32.77
		UN	120	53.54	35.38
11	265	AND	114	54.44	28.00
		ARCO	119	45.33	31.19
		UN	116	54.29	31.93
12	235	AND	121	52.18	26.63
		ARCO	116	45.55	27.36
		UN	116	48.89	25.82
13	235	AND	120	46.40	32.01
		ARCO	113	48.41	31.98
		UN	114	51.75	33.03

CYBEX TESTS RESULTS AT 300 DEGREES PER SECOND CONT.

SUB	BW	COND	AVROM	TAEQ	TAEH
14	175	AND	126	33.25	21.84
		ARCO	127	35.93	23.32
		UN	122	33.96	18.82
15	167	AND	133	35.88	28.31
		ARCO	128	34.93	23.47
		UN	128	40.35	29.98
16	236	AND	117	44.51	22.92
		ARCO	116	44.20	24.01
		UN	111	46.58	20.00
17	265	AND	128	52.30	33.96
		ARCO	116	55.09	25.65
		UN	124	48.16	31.01
18	253	AND	119	47.82	33.76
		ARCO	123	49.83	31.74
		UN	119	46.29	31.76
19	241	AND	112	49.76	25.62
		ARCO	109	41.76	24.16
		UN	114	47.71	27.44
20	180	AND	124	34.46	19.58
		ARCO	126	39.10	22.72
		UN	115	35.91	20.00

CYBEX TEST RESULTS AT 300 DEGREES PER SECOND CONT.

SUB	BW	COND	AVROM	TAEQ	TAEH
21	207	AND	121	47.03	20.83
		ARCO	123	48.23	25.81
		UN	123	48.39	32.04
22	212	AND	122	31.79	21.10
		ARCO	128	32.03	23.31
		UN	121	40.37	23.40
23	212	AND	104	41.52	25.73
		ARCO	96	54.14	29.12
		UN	100	46.01	27.39
24	202	AND	122	42.21	29.65
		ARCO	115	44.38	32.75
		UN	125	48.19	28.18
25	225	AND	120	43.13	29.64
		ARCO	129	41.17	24.55
		UN	120	48.02	26.46
26	265	AND	114	56.92	37.22
		ARCO	121	41.98	31.32
		UN	117	44.28	33.67

CYBEX TEST RESULTS AT 300 DEGREES PER SECOND CONT.

SUB	BW	COND	AVROM	TAEQ	TAEH
27	226	AND	116	34.35	14.13
		ARCO	106	42.82	27.77
		UN	112	40.39	24.73
28	257	AND	124	41.04	30.59
		ARCO	125	46.45	29.12
		UN	120	47.36	31.02
29	245	AND	126	44.72	27.45
		ARCO	116	56.21	26.41
		UN	119	46.42	27.23
30	279	AND	126	51.24	25.53
		ARCO	125	52.04	29.67
		UN	122	60.42	31.67
31	220	AND	109	51.88	37.93
		ARCO	116	51.95	35.40
		UN	109	58.91	37.66
32	212	AND	119	30.47	24.52
		ARCO	125	30.73	24.67
		UN	123	32.51	30.38

RAW DATA: CYBEX TESTING RESULTS FOR KNEE EXTENSION AND KNEE FLEXION AT 300 DEGREES PER SECOND JOIINT ANGLE VELOCITY

SUB	COND	AVPQ	AVPH	ENDQ	ENDH
1	AND	321	159	53	46
	ARCO	282	133	52	52
	UN	350	146	47	30
2	AND	266	145	36	27
	ARCO	329	162	37	15
	UN	336	186	39	30
3	AND	251	160	49	37
	ARCO	280	174	44	24
	UN	236	172	59	51
4	AND	301	187	42	36
	ARCO	322	157	42	45
	UN	248	179	30	28
5	AND	369	220	48	63
	ARCO	369	202	47	65
	UN	376	224	60	66
6	AND	253	164	47	15
	ARCO	320	184	55	42
	UN	326	174	45	33

CYBEX TEST RESULTS AT 300 DEGREES PER SECOND CONT.

SUB	COND	AVPQ	AVPH	ENDQ	ENDH
7	AND	360	204	41	22
	ARCO	387	242	42	29
	UN	339	227	38	28
8	AND	272	157	54	31
	ARCO	369	245	53	41
	UN	280	208	43	45
9	AND	303	159	63	36
	ARCO	306	136	58	29
	UN	288	149	84	44
10	AND	336	206	68	40
	ARCO	308	185	73	39
	UN	347	221	56	36
11	AND	334	169	50	38
	ARCO	304	147	51	35
	UN	350	165	52	25
12	AND	277	136	45	18
	ARCO	311	171	47	32
	UN	304	174	56	47
13	AND	299	129	43	46
	ARCO	276	115	41	16
	UN	328	134	42	33

CYBEX TESTS RESULTS AT 300 DEGREES PER SECOND CONT.

SUB	COND	AVPQ	AVPH	ENDQ	ENDH
14	AND	249	169	43	39
	ARCO	240	158	44	40
	UN	267	174	44	39
15	AND	234	149	58	33
	ARCO	214	159	55	40
	UN	254	185	54	46
16	AND	265	63	58	20
	ARCO	267	98	51	27
	UN	247	47	53	8
17	AND	423	193	53	18
	ARCO	434	219	56	25
	UN	362	249	53	36
18	AND	251	180	46	40
	ARCO	280	199	47	39
	UN	306	199	51	30
19	AND	323	179	51	45
	ARCO	307	147	56	45
	UN	316	185	51	43
20	AND	197	145	42	25
	ARCO	197	121	49	28
	UN	235	147	42	33

CYBEX TEST RESULTS AT 300 DEGREES PER SECOND CONT.

SUB	COND	AVPQ	AVPH	ENDQ	ENDH
21	AND	337	145	56	61
	ARCO	354	182	63	64
	UN	341	229	60	50
22	AND	253	141	57	40
	ARCO	262	154	58	35
	UN	271	165	31	40
23	AND	322	132	61	32
	ARCO	347	127	60	56
	UN	326	104	54	20
24	AND	285	169	43	27
	ARCO	313	178	50	29
	UN	308	155	43	31
25	AND	249	171	48	50
	ARCO	264	176	46	53
	UN	259	184	47	32
26	AND	474	254	62	47
	ARCO	394	222	58	50
	UN	396	228	55	37
27	AND	292	80	102	85
	ARCO	326	101	68	39
	UN	283	119	71	22

CYBEX TEST RESULTS AT 300 DEGREES PER SECOND CONT.

SUB	COND	AVPQ	AVPH	ENDQ	ENDH
28	AND	351	219	60	37
	ARCO	262	159	51	37
	UN	345	213	53	43
29	AND	308	191	40	22
	ARCO	306	133	41	21
	UN	345	185	50	32
30	AND	342	155	42	52
	ARCO	406	197	37	34
	UN	387	165	43	34
31	AND	352	187	48	18
	ARCO	364	199	50	20
	UN	374	212	45	21
32	AND	265	115	78	34
	ARCO	283	147	53	25
	UN	289	149	62	19

The vita has been removed from the scanned document