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The Female Adolescent Knee

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THESIS APPROVAL

The abstract and thesis of Patti J. Seely for the Master of Science in Health Education were presented October 22, 1998 and accepted by the thesis committee and the department.

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ABSTRACT

An abstract of the thesis of Patti J. Seely for the Master of Science in Health Education presented October 22, 1998.

Title: The Female Adolescent Knee.

Many lower extremity anomalies are linked to an increased incidence of knee pain. A relationship between increased sports participation and knee pain has also been hypothesized. This study examined the relationship between lower extremity anomalies and the level of sports participation to knee pain. Fifty middle and high school female students completed a questionnaire to determine level of sports participation and the presence of knee pain/pathology. Measurements were made of Q angle, iliotibial band flexibility, knee hyperextension, hamstring flexibility, patella alta and calcaneal position. All variables were quantified and correlation coefficients were calculated. Stepwise multiple regression was used to evaluate relationships among the variables. No significant relationships were found between knee pain/pathology and the level of sports participation. No significant relationships were found between knee pain/pathology and the lower extremity measurements. The anatomical measurements most strongly related to knee pain/pathology were hamstring flexibility of the right leg ($r = .27$) and the right Q angle ($r = .24$). The multiple regression analysis revealed 14.7% shared variance between scores on the pain scale and right hamstring flexibility,

right iliotibial band flexibility, and left iliotibial band flexibility. The study also indicated the need to standardize measurement techniques and provided additional means and ranges for the lower extremity measurements made. The values found were within the established normal ranges reported in the literature.

THE FEMALE ADOLESCENT KNEE

by

Patti J. Seely

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THE FEMALE ADOLESCENT KNEE

INTRODUCTION

It has been reported that new injury patterns are developing as the number of children and adolescents in organized sports increases -- injury patterns are emerging that were not apparent when youths spent most of their sport and fitness time in free play (ACSM, 1993). The more a youth or teenager participates in sports, the higher the risk of injury (Overbaugh and Allen, 1994). Micheli and Foster (1993) reported that the knee was the most frequent site of injury in most childhood sports, and injuries involving the patellofemoral articulation have been reported to be significantly more frequent among females (DeHaven and Lintner, 1986).

STATEMENT OF THE PROBLEM

Injuries are increasing as the intensity of sports participation increases in youth. Particularly disconcerting is the disproportionate incidence of knee pain and pathology in adolescent and college-age females. Is there a relationship between lower extremity anatomical measurements and the incidence of knee pain and pathology? Are there sufficient and appropriately designed studies that have examined the relationship between lower extremity anomalies and the incidence of knee problems? Is knee pathology related purely to intensity of sports participation? Is pathology a function of both? This study attempted to provide additional information concerning the relationship(s) between these variables by investigating these questions.

HYPOTHESES

There is a relationship between knee pain and/or pathology and lower extremity malalignment. There is a relationship between knee pain and/or pathology and sports participation which includes the amount of time spent in organized sports practice, organized sports games or competition, and individual exercise programs.

PURPOSE OF THE STUDY

The purpose of this study was to examine the relationship between a number of lower extremity anatomical parameters and the incidence of knee pain/pathology in adolescent females. The study also examined the relationship between sports participation and knee pain/pathology.

SIGNIFICANCE OF THE STUDY

There is evidence to suggest that anatomical malalignment of the lower extremities is correlated with an increased incidence of patellofemoral dysfunction and knee pathology (Aglietti, Insall, and Cerulli, 1983; Horton and Hall, 1989; McConnell, 1986; Puniello, 1993; Winslow and Yoder, 1995). However, not all studies have revealed a significant relationship (Fairbank, Pynsent, van Poortvliet, and Phillips, 1984). The intensity of participation in sports has also been hypothesized to be a primary factor (Fairbank et al., 1984). There is general agreement that the incidence of knee injuries is increasing and this is especially true for females (Dehaven and Lintner, 1986). Previous studies included both males and females in their subject samples, and included a wide range of ages in some cases (Fairbank et al., 1984; McConnell, 1986; Horton and Hall, 1989; and Puniello, 1993). No attempt has been made to quantify the level of sports participation.

This study used anatomical (anthropometric) measures of the lower extremity that required minimal equipment or technical expertise, and included a newly developed measure of the level of intensity of sports participation of adolescent females. The primary goal of this applied research was to examine the relationship between the variables. A significant relationship found between anatomical measures and increased knee pain would presumably result in the development of screening programs that could be easily implemented. Such programs could allow more long-term injury-free participation in athletic programs for adolescent females, and corrective measures for some malalignment problems could be more consistently implemented.

DELIMITATIONS

1. Populations to which the results of this study can be generalized include adolescent females aged 12 to 18.
2. Anatomical parameters measured were limited to those requiring little training or technical skill, and having minimal equipment requirements.
3. Results can be generalized only to the sports in which the adolescent female subjects in this study participated, and include soccer, basketball, gymnastics, swimming, tennis, and track and field.
4. Subjects with previous treatment for lower extremity malalignment or other lower extremity trauma were excluded.

LIMITATIONS

1. Randomization was not possible. Subject recruitment included soliciting volunteers from Portland area middle and high schools.
2. Although females in this study participated in a variety of recreational and organized sports programs, they were not involved in each sport equally (i.e., some subjects participated in only one sport/activity while other subjects participated in several sports).
3. Radiologic confirmation of measurements was not possible.
4. Subject recall was used to assess participation in sports activities.

ASSUMPTIONS

1. Questionnaires were answered honestly, and completely by all study participants.
2. Anatomic measurements were valid and reliable.
3. The subjects were representative of females of similar age.
4. Directions were understood and completely followed by all subjects.

OPERATIONAL DEFINITIONS

The subjects of the study were adolescent females 12 to 18 years of age. The dependent variable was a measure of the amount of knee pain/pathology. The level of knee pain/pathology was determined with a questionnaire that quantified the occurrence and intensity of certain symptoms. The independent variables included 1) anatomical parameters measured in the lower extremities, and 2) sports participation. The lower extremity measurements included hamstring flexibility, calcaneal position (subtalar joint pronation), Q (quadriceps) angle, knee hyperextension (genu recurvatum), iliotibial band flexibility and patella alta (high riding patella).

The level and intensity of sports participation was a quantitative measure obtained with a questionnaire developed by the principal investigator. Subjects recalled the number of hours per week spent in sports training, exercise and games. Also assessed were the number of seasons involved in sports as well as the number of sports per season.

CHAPTER II

REVIEW OF THE LITERATURE

This literature review includes information concerning the incidence of knee problems in the female--primarily in the adolescent female--and discusses the possible etiology of knee pain and pathology as related to this study. Finally, previous studies that examine the relationships between knee malalignment and intensity of sports participation to knee pain/pathology are reviewed.

INCIDENCE

A number of the articles reviewed presented information based on epidemiological study. DeHaven and Lintner (1986) conducted a survey of the injuries that were treated at the University of Rochester Section of Sports Medicine over a seven year period. They reported that 59.2% of female injuries were to the knee. The ankle was the second most frequently injured area at 13.1%. Aside from the category of injuries to the patellofemoral articulation, males showed a predominance in injuries with a male:female ratio of at least 2.4:1. Recurrent patellar dislocation (RPD)/subluxation and acute patellar dislocation departed sharply from this trend. Females accounted for more cases of injury to the patellofemoral articulation than did males despite males constituting greater than 80% of the patient sample in one study (DeHaven and Lintner, 1986). Each of these diagnoses accounted for a significantly higher number of injuries to females than of injuries to males. Also, sports common to males and females exhibited increased frequencies of recurrent patellar dislocation/subluxation in comparison to sports in which only males participate. For example, both males and females participate in soccer and basketball and the frequency of RPD/subluxation is higher in these sports than in football, a sport in which only males participate. Among basketball players, however, females had a significantly higher frequency of RPD/subluxation than did males, but this difference was not observed among soccer players (the frequency of acute patellar dislocation did not vary significantly between the sexes in these sports) (DeHaven and Lintner, 1986).

The difference in the frequency of RPD between male and female basketball players may be due to other factors. Perhaps the nature of basketball, which includes a greater amount of jumping, coupled with gender differences in lower extremity anatomy, predisposes players to RPD/subluxation (DeHaven and Lintner, 1986).

Traditionally, patellofemoral pain has been thought of as a condition that affects overweight adolescent girls with genu valgum ("knock kneed"), or when the slope of the upper leg angles toward the midline. This is contradicted by the fact that 89% of the subjects in one study (Doucette and Goble, 1992) were adolescent girls, but the majority of these girls were characterized as thin and athletic.

The increase in the incidence of knee injuries and pathology is an important health issue for female athletes. Research is needed to identify possible mechanisms for the increased incidence. Prevention strategies which are currently nonexistent or inadequate depend upon identifying these mechanisms.

ETIOLOGY

Patellofemoral pain, knee pathology, and knee injuries are common among adolescent and young adult females. The etiology of these problems remains controversial. The causes and mechanisms involved may be of an extrinsic or intrinsic nature. Extrinsic causes include wasting and weakness of the vastus medialis oblique (the medial quadriceps muscle), an increased Q angle, patella alta, femoral rotation, femoral neck ante-version, variation in patellar shape, genu valgum, tibial torsion, patellar instability, an increased sulcus angle, direct trauma, overuse of the medial facet, and under-use of the odd facet. Suggested intrinsic factors include primary abnormalities of the articular cartilage or the subchondral bone, poor healing after minor trauma, and racial difference (Fairbank et al., 1984).

Kramer (1986) has identified three groups of causative factors that can alter the normal patellar alignment and cause pain. The first of these abnormalities involves the patellofemoral articulation and includes an increased sulcus angle, patellar tilt, and patella alta. The second group of causative factors is related to the surrounding soft tissue and includes weakness or atrophy of the vastus medialis, hypertrophy of the vastus lateralis, medial laxity and/or lateral tightness of the patellar retinaculum, and generalized joint laxity. The final group of conditions includes lower extremity malalignments which alter the Q angle, such as an increased breadth of the hips in relationship to femoral length, genu recurvatum, pes planus and foot pronation.

Further description of some of the key causative factors reveals some interrelationships. For example, an increased Q angle has been associated with recurrent subluxation, chondromalacia or patellofemoral arthralgia. The Q angle is defined as the angle between a line connecting the anterior superior iliac spine (ASIS) and the midpoint of the patella and the tibial tubercle (Guerra, Arnold, and Gajdosik, 1994). The Q angle is the result of the pulling forces of the quadriceps tendon and of the patellar tendon which draw the patella laterally. Theoretically, greater Q angles increase the lateral pull of the quadriceps femoris muscle on the patella and potentiate such disorders as chondromalacia patella or recurrent lateral subluxation of the patella (Horton and Hall, 1989). An increased Q angle is also associated with increased femoral ante-version, external tibial torsion and lateral displacement of the tibial tubercle (McConnell, 1986).

Chronic retinacular strain has also been indicated as a cause of knee pain. Patellofemoral pain in the young is frequently a soft tissue problem initially, but aberrant mechanics (particularly lateral tracking) cause this retinacular overuse and pain may eventually lead to synovial irritation and chondromalacia (Fulkerson, 1989).

Tight hamstrings increase the stress put on the patellar tendon with running, walking, and knee extension (Jacobson and Flandry, 1989). Eilert (1993) reported that a hamstring contracture caused a dynamic knee flexion deformity that produced anterior overload on the patellofemoral joint. Patellar overload syndrome is not well understood, and usually occurs in active participants in sports and vigorous recreational activities such as running, jumping, climbing stairs and activity with increased hamstring involvement.

According to Shelton and Thigpen (1991), decreased flexibility of the gastrocnemius-soleus muscle group causes compensatory pronation of the foot, resulting in increased tibial rotation that increases patellofemoral stress.

Pronation of the subtalar joint is accompanied by a prolonged internal rotation of the leg, resulting in malalignment of the patella and internal rotation of the femur (McConnell, 1986).

Patella alta, or a "high riding patella", exists when the infra patellar tendon is longer than the greatest diagonal length of the patella. Under normal circumstances the ratio between the two approximates unity. Patella alta has been associated with recurrent subluxation and chondromalacia (Kramer, 1986).

PREVIOUS STUDIES

A number of studies have examined the relationship between anatomical abnormalities and the incidence of knee pain and pathology (Aglietti et al., 1983;

Fairbank et al., 1984; Horton and Hall, 1989; McConnell, 1986; Puniello, 1993; and Winslow and Yoder, 1995). Some studies have also considered the role of intensity of sports participation. A study by Fairbank et al. (1984) attempted to identify the mechanical abnormalities of the patellofemoral joint that have been implicated in causing adolescent knee pain. These results were compared to a number of hospital outpatients who presented with anterior knee pain. They found that the proportion of pupils with knee pain who reported a wish to play sports as much as possible was significantly greater than a group of pupils without knee symptoms (Fairbank et al., 1984). The authors also found no relationship between knee symptoms and the Q angle, valgus plane or patella alta in this group of 13 to 17 year old school children. The result for the hospital outpatients was comparable. They found no correlation between limb morphology and knee pain except that women patients showed a difference in ratios of femoral rotation in extension compared with the school girls. There was a concomitant increase in the ratio of tibial rotations, a change not seen in boys and men. This medial pressure and overloading may be exacerbated by the difference in hip and knee rotation in the female. The authors were therefore unable to identify any anthropometric factor that could distinguish the pupils with knee symptoms from those without symptoms. The authors concluded that chronic overloading rather than faulty mechanics was the dominant factor in anterior knee pain in the adolescent (Fairbank et al., 1984). The number of female subjects with symptoms in the hospital patient group was 38 compared to 14, men showing a continued trend for an increased incidence in females. A comparison of the hospital group and the school group could not be made because of the age difference. The study also did not attempt to quantify the actual amount of sports play participation by the subjects. A wish to play and the actual quantification of intensity of play require clarification.

McConnell (1986) examined the effectiveness of a treatment program in patients with patellofemoral pain syndrome. The subjects of the study were females (n=20) and males (n=15) 12 to 37 years of age. Part of the pretreatment evaluation included the measurement of the Q angle, iliotibial band tightness, the amount of pronation of the foot, "squinting patella" (when the patella face medially in stance), knee hyperextension, hamstring flexibility, and leg length. The most common malalignment characteristics reported were pronated feet, tight iliotibial band and "squinting patella". Tight hamstrings and an increased Q angle were also common findings. The techniques used to measure and assess these parameters were not described.

Horton and Hall (1989) conducted a study to document and describe normal Q angle values in a young, adult population (mean age=22.6 years) and to identify relationships between Q angle, gender, hip width and femur length. They reported that increased Q angles indicate the presence of pathological lateral forces on the patella. They further hypothesized that if women do have greater Q angles than men, this could put them at greater risk than men for developing patellofemoral joint problems. Support for the findings of Horton and Hall (1987) was published in the previous work by Hvid, Anderson and Schmidt (1981) and Yates and Grana (1986). Hvid et al., (1981) measured the Q angles of 12 women and 10 men who were treated nonoperatively for chondromalacia, and their data showed that 11 of the 12 women had Q angles of at least 15 degrees and 7 women had angles greater than 20 degrees. Only one male subject had a Q angle greater than 15 degrees. In a prospective study of patellofemoral pain, Yates and Grana (1986) found that patellofemoral problems were most common among young women. Fifty-one of the painful knees (76% of the total) in their study belonged to women. Thus, this research suggests that women have larger Q angles and a greater incidence of patellofemoral joint pain than do men. Horton and Hall (1989) reported that 22% of the healthy female subjects in their study had Q angles from 20 to 25.5 degrees without any symptoms of pathology, and therefore increased Q angle alone does not result in these knee pathologies (Horton and Hall, 1989).

Stretching of the iliotibial band has been advocated in the literature to treat patellofemoral dysfunction, but there is little research investigating the relationship between iliotibial band tightness and patellofemoral dysfunction. Puniello (1993) investigated the relationship between iliotibial band tightness and medial glide of the patella in patients with patellofemoral dysfunction. The subjects in this study were from 13 to 47 years of age; all but one were female, and all but two were involved in athletics. A tight iliotibial band, as indicated by Ober's test, was found in 70% of the patients with patellofemoral dysfunction. The results therefore support a relationship between iliotibial band tightness and patellofemoral dysfunction due to decreased medial glide of the patella. The author noted that the Ober's Test requires an experienced examiner using proper positioning and stabilization of the pelvis and lower extremity. The author also reported that there continues to be some discrepancy about how patellar glide stretches the lateral retinaculum. Intertester and intratester reliability studies were recommended for these assessment techniques.

Winslow and Yoder (1995) assessed the relationship between iliotibial band tightness and patellofemoral pain in ballet dancers. The results of their study supported a previous study by Reid, Burnham, Saboe, and Kushner (1987) of ballet dancers and reported that patterns of decreased flexibility in classical ballet dancers are positively correlated with an increased incidence of lateral hip and knee injuries. Their results showed that iliotibial band tightness in ballet dancers may be a predisposing factor for the development of patellofemoral pain. Dancers with iliotibial band tightness tend to compensate for the tightness during demi plie with excessive external rotation of the tibia which may further exacerbate the patellofemoral pain (Winslow and Yoder, 1995).

Aglietti et al.(1983) compared the Q angle, patellar height (two methods), sulcus angle, and congruence angle in one hundred fifty symptomatic subjects with no history or physical finding of pathology of the knee and ninety subjects with knee symptoms. The average age for the asymptomatic group was 23 years and the average age for the symptomatic was 21 years. The authors found that in normal knees the average quadriceps angle measured 15 degrees, the patellar length was equal to the patellar ligament length and the average congruence angle was -8 degrees (SD: + or - 6 degrees). Abnormalities were found in the 90 symptomatic knees (high riding patella and shallow femoral sulcus). They also found that the congruence angle was grossly abnormal. In knees with clinically diagnosed chondromalacia, the Q angle was increased and there was mild incongruence of the patellofemoral joint. The study therefore supported the hypothesis that anatomic variation is important in the etiology of patellar instability and pain (Aglietti et al., 1983).

PREVENTION

Although there is some evidence to suggest that anatomical malalignment of the lower extremities is correlated with an increased incidence of patellofemoral dysfunction and knee pathology, the intensity of participation in sports is also thought to be a primary factor. Because the incidence of knee injuries in females appears to be increasing, it is important to examine methods for preventing these injuries. Approximately 50% of overuse injuries sustained by active children and adolescents are preventable (ACSM, 1993). It should be possible to reduce both the number and severity of sports injuries in this group of young athletes. Ostrum (1993) stated that prevention is the area that is lacking, especially in pediatrics. The author argued that there is a level of conditioning that high school and collegiate athletes must maintain, and any decease in the level of conditioning presumably results in a corresponding increase in an injury rate. Backx, Hein, Beijer, Bol, and Erich (1991) advocated teaching practical exercises in physical education along with providing a theoretical foundation in biology lessons.

Overbaugh and Allen (1994) have emphasized the need for preseason stretching and strengthening programs to decrease muscle imbalances and decrease forces exerted across the knee joint. To prevent knee injuries, certain exercises should be avoided, proper foot wear is essential, and the athletes should be screened for abnormalities such as increased hip internal rotation, tibial torsion, foot pronation, vastus medialis oblique weakness and tight heelcords and hamstrings.

Rifat, Ruffin, and Gorenflo (1995) studied the relative frequency of disqualifying criteria in a complete history and physical sports examination. They reported that the musculoskeletal examination often produces the highest yield of abnormal findings in the preparticipation physical evaluation (PPE). Traditionally, the exam has employed a screening format with attention to areas of previous injury, in addition to a more thorough evaluation of the ankle and knees. A thorough musculoskeletal evaluation should be a prime focus in the PPE.

Backx et al. (1991) reported that an important goal of the World Health Organization is a substantial reduction in sports injuries, both in extent and severity, before the year 2000. Realization of this goal for significant injury reduction calls for a structured plan of preventive measures. There are four steps to this structured plan. The first step is to acquire data concerning the nature, extent, and severity of sports injuries. The second step is to identify the etiology involved in the sports injuries. The third step is to apply one or more measures based on identified etiologic factors to prevent sports injuries or reduce their severity. The fourth step involves evaluating the applied preventive measures in order to compare the incidence and severity before and after the intervention.

On the basis of previous research and the goals of the World Health Organization it is important to continue studying the incidence of knee problems, especially in adolescent females. This research was designed to investigate the relationship between various lower extremity malalignment variables and the incidence of knee pain/pathology in middle and high school females. The relationship between knee pain/pathology and competitive sports participation was also examined.

CHAPTER III

METHODS

Subjects

The sample for the study consisted of 32 middle school females and 18 high school females from Portland and Beaverton, Oregon area schools. Subject characteristics are presented in Table 1. All subjects were recruited from physical education or weight training classes and were excluded if they had previous major trauma to the lower extremities (e.g., fractures, severe sprains or strains). Written consent was obtained from both the student and her parents or guardians (Appendix A), and all procedures were approved by the Portland State University Human Subjects Research Review Committee.

TABLE 1

Subject Characteristics: (n=50)

	Mean	Standard Deviation	Range
Age (yr)	13.5	1.3	12.0-18.0
Height (m)	1.6	0.07	1.5-1.8
Weight (kg)	55.4	10.5	34-91

Procedures

Pilot testing was completed to develop a questionnaire for the assessment of sports participation. Reviewers examined the format, content, expression and importance of items. Items were also reviewed for clarity and appropriateness. The questionnaire was administered to five adolescent females as part of the pilot study. Redundancy was minimized by the identification of questions with similar answers. A trial run of the scoring of the questionnaire answers was completed and the method for analysis of questionnaire responses was determined.

Officials in the Portland and Beaverton School Districts were contacted for permission to conduct the research. Once approval was granted, the physical education instructors and principals at several of the middle schools (grades 6 through 8) and high schools (grades 9 through 12) were asked to assist in recruiting subjects. With the physical education instructors' help, packets were distributed in the physical education classes to interested female students. The packets contained consent forms and the questionnaire (Appendix B). When the packets were returned, the female students were scheduled for the lower extremity measurements. All questionnaires were scored and anatomical measurements performed exclusively by the principal investigator.

Initially at each session, the consent form and questionnaire was reviewed with the subject to clarify answers if needed. The subject was then measured. Measurements of right and left legs included hamstring flexibility, calcaneal/subtalar position, Q (quadriceps) angle, genu recurvatum, iliotibial band flexibility, and patellar length/patellar tendon length ratios. All measurements were made in accordance with standards of practice commonly used in physical therapy. Raw data are presented in Appendix C. One measurement trial was completed unless the investigator noted an unusual discrepancy between the right and left measurements. If the subject did not maintain the correct posture/position during testing, another measurement was completed after the subject was repositioned. All goniometer measures were made to the nearest degree with a Standard Baseline goniometer. Linear measurements were made to the nearest 1.0 centimeter with a standard ruler.

Hamstring flexibility was measured with the subject supine as described by Jacobson and Flandry (1989). The subject was instructed to hold the thigh so that the hip was at a 90 degree angle. The subject was then asked to straighten the knee as far as possible. The measurement was made with a goniometer and was recorded to the nearest degree as number of degrees from full extension of the knee. The arms of the goniometer were aligned with the shaft of the femur and lateral malleoli, with the axis of movement at the knee joint. The measurement was recorded as a negative number of degrees from full extension of the knee unless full extension was obtained.

Calcaneal position/subtalar position was measured by first having the subject lie prone on the examination table. Subtalar neutral was palpated and a line drawn down the posterior lower leg (Achilles tendon). The subject then stood on two parallel strips of tape that were 12 inches apart. The second toe and the center of the heel of each foot were placed on the strips of tape to standardize foot position. The angle was then measured with a goniometer to the nearest degree along the Achilles tendon and the center of the calcaneus.

Q (quadriceps) angle measurement was based upon the research of Guerra, Arnold, and Gajdosik (1994) and was measured while the subject was standing with the quadriceps relaxed. Foot placement was standardized with two parallel strips of tape 12 inches apart; the second toe and center of the heel of each foot were positioned on the strips of tape. The anterior superior iliac spine (ASIS) was palpated, and anatomical marks were made in the center of the patella and middle of the tibial tubercle. One arm of the goniometer was aligned along an imaginary line from the ASIS to the center of the patella and the other arm was aligned along a line from the center of the patella to the tibial tubercle. The measurement was recorded to the nearest degree.

Knee hyperextension (genu recurvatum) was measured with a goniometer along the long axis of the femur and the long axis of the fibula to the lateral malleoli with the axis of motion at the knee joint and recorded to the nearest degree. Hyperextension was measured as a negative value and knee flexion was recorded as a positive value. The measurement was made with the subject standing and foot placement standardized.

Puniello (1993) outlined the procedure for Ober's Test which was used to measure iliotibial band flexibility. The subject assumed a side lying position with the knee of the bottom leg flexed to 90 degrees. The trunk was stabilized by the subject's hand. The upper leg was flexed to 90 degrees at the knee and the hip was brought from flexion and abduction to neutral (extended to be in line with the trunk) with neutral rotation and then allowed to adduct. The measurement was recorded as the distance in centimeters between the exam table and the medial condyle of the femur.

Patella length/patellar tendon length ratio was obtained with the subject sitting and the leg supported so the knee was at 30 degrees of flexion. The length of the patella and the length of the patellar tendon were then measured. Anatomical marks were made at the superior and inferior poles of the patella to measure patellar length. The center of tibial tubercle was also marked and patellar tendon length denoted as the distance from the inferior pole of the patella to the tibial tubercle. The lengths were recorded to the nearest centimeter. The ratio was calculated as the patellar length divided by the patellar tendon length.

After all lower extremity measurements were completed, scores for pain scale and level of sports participation were obtained. Table 2 contains the means, standard deviations and ranges for all variables. Figures 1 through 14 in Appendix D depict the frequency distribution for each variable.

Data Analysis

Pearson Product-Moment correlation coefficients were calculated to estimate the relationship between the pain scale and each of the other variables. An alpha level of .05 was used to denote statistical significance. Stepwise multiple regression was used to further evaluate the relationships between the variables. All data analysis was completed with Microsoft Excel (version 5.0) and SPSS for Windows (version 6.0).

TABLE 2

Descriptive data for lower extremity measurements, pain scores, and sports participation scores (n=50).

	Mean	Standard Deviation	Range
Q Angle R	12.7	3.8	5-22
(Degrees) L	13.3	4.5	5-20
Knee Hyperext. R	-0.3	6.1	-15-+10
(Degrees) L	-0.4	6.0	-16-+10
I. T. Band Flex. R	7.0	5.8	0-21
(Centimeters)L	7.1	5.3	0-22
Hamstring Flex. R	-21.8	16.4	0- -48
(Degrees) L	-21.8	16.0	0- -45
Pat./Pat.Ten. R	1.1	.2	.7-1.4
Length (Ratio) L	1.1	.2	.7-1.4
Calcaneal Pos. R	6.7	4.1	0-20
(Degrees) L	7.3	4.4	0-20
Pain Score	13.9	9.7	0-41
Sports Part. Score	34.4	14.9	12-84

CHAPTER IV

RESULTS

No statistically significant relationship was noted between the scores on the pain scale and the level of sports participation in this sample of subjects. Correlation coefficients were also small and not statistically significant when the high school subjects and middle school subjects were analyzed separately. Table 3 shows the correlation coefficients estimating the relationship between pain scale scores and all other variables. Appendix E contains the intercorrelation matrix for all variables. The anatomical measurements showing the strongest relationship with the scores on the pain scale were the measurements for the right hamstring flexibility ($r = .27$) and the right Q angle ($r = .24$).

Stepwise multiple regression analysis revealed only 5.7 % shared variance between scores on the pain scale and right hamstring flexibility. Right hamstring flexibility and right iliotibial band together increased R Square to 9.2%. The addition of left iliotibial band measurements increased R Square to 14.7% after which the variable selection criterion was exceeded; the stepwise selection of variables was terminated. Table 4 provides the summary statistics for the regression analysis at the last step of the regression analysis.

TABLE 3

Pearson Product-Moment Correlation Coefficients (versus pain score)

	All Subjects (n=50)	Middle School (n=32)	High School (n=18)
Q Angle R	0.24	0.23	0.22
(Degrees) L	0.19	0.14	0.28
Knee Hyperext. R	-0.05	-0.1	0.1
(Degrees) L	-0.06	-0.17	0.14
I.T. Band Flex. R	-0.23	-0.21	-0.21
(Centimeters) L	0.08	-0.03	-0.08
Hamstring Flex. R	0.27	0.28	0.29
(Degrees) L	0.11	0.16	0.09
Pat./Pat.Ten. R	0.01	-0.13	0.28
Length (Ratio) L	-0.01	0.23	-0.3
Calcaneal Pos. R	-0.22	-0.12	-0.4
(Degrees) L	-0.04	-0.03	0.01
Sports Part. Score	0.07	0.06	0.07

TABLE 4

Summary statistics for step 3 of regression analysis

Variable	B	SE B	Beta	T	Sig T
Step 1` Ham Flex R	0.249	0.112	0.302	2.225	0.031
Step 2 I.T.Band L	0.968	0.483	0.53	2	0.0514
Step 3 I.T.Band R	-1.15	0.442	-0.682	-2.6	0.013
Constant	21.076	3.125		6.74	0
Multiple R	0.448				
R Square	0.201				
Adjusted R Square	0.147				
Standard Error	8.99				
Analysis of Variance					
	DF		Sum of Squares		Mean Square
Regression	3		913.2		304.39
Residual	45		3636.15		80.8
	F=	3.77	Signif F=	0.017	

CHAPTER V

DISCUSSION

The results of this study partially support the findings of Fairbank et al. (1984); no strong relationships were found between the anatomical measures and pain levels/symptoms. Fairbank et al. (1984) reported that higher pain levels were related to "the desire to play sports as much as possible". The method to determine sports activity level in the Fairbank et al. (1984) study was based upon a questionnaire that asked students how much they enjoyed sports, not how much they actually participated. The questionnaire for the present study was formulated to obtain a more precise indicator of sports participation. These findings showed that there was no statistically significant relationship between sports participation and pain level in this group of female students.

Other studies have reported relationships between various anatomical measures and knee pain (Horton and Hall, 1989; Aglietti et al., 1983; Winslow and Yoder, 1995; McConnell, 1986; and Puniello,1993). Unlike the studies by Horton and Hall (1989) and Aglietti et al. (1983), no significant relationship was found between Q angles and painful knees in this study. Winslow and Yoder (1995) found a relationship between iliotibial band tightness and knee problems. McConnell (1986) reported that the most common problem with anterior knee pain was a tight iliotibial band. No significant correlation between pain levels and iliotibial band tightness was found in the sample of female students used in this investigation.

In this study, tightness of the right hamstring revealed the strongest correlation with reported pain levels. McConnell (1986) reported that tight hamstrings were a common finding in patients with knee pain. The difference between the measurements obtained of right and left legs was unexpected, and was also reported in other studies.

Patella alta was not correlated with knee pain in the Fairbank et al. (1984) study. Aglietti et al. (1983) reported finding patella alta in symptomatic knees. This study found no relationship between patella length/patellar tendon length ratios and knee pain.

Many of the previous studies used the same anatomic measures used in this study. Fairbank et al. (1984) also examined Q angle, and reported measurements that were larger than those reported in this study and other studies. Fairbank et al. (1984) found the average right Q angle for painful knees was 23.4 degrees and 24.8 degrees for knees without pain. The average left Q angle was 21.7 degrees for painful knees and 22.7 degrees for knees without pain. Q angle measurements were made with their subjects standing and the foot position standardized.

Horton and Hall (1989) classified Q angles of 15 degrees as normal and those over 20 degrees as abnormal. The American Orthopedic Association considers 10 degrees normal for Q angle and over 15 to 20 degrees as abnormal (Horton and Hall, 1989).

Aglietti et al. (1983) found Q angles of 17 degrees in women without knee pain and 19 degrees in those reporting pain. Their measurements were performed with subjects supine. McConnell (1986) reported an upper limit for a normal Q angle of 13 to 15 degrees but did not describe the method of measurement. Guerra, Arnold, and Gajdosik (1994) found a mean Q angle of 13.5 degrees in adult women; measurements were made with the subject standing. Foot position was standardized and the quadriceps were relaxed.

This study obtained a median Q angle of 12 (+or-3.8 degrees) for the right knee and a Q angle of 13 (+or- 4.5) degrees for the left knee. The Q angles are therefore considered within normal ranges reported in the literature and compare with studies cited here except for the results obtained by Fairbank et al. (1984). Fairbank et al. (1984) studied students; subjects in the other studies included adults.

Patellar ratios were obtained by Agliett et al. (1983) with the subjects sitting and the knee flexed to 30 degrees. They found patellar length equal to patellar tendon length. The mean ratio was 1.06 (+or- .12). Fairbank et al. (1984) found average ratios of 1.05 in right painful knees and 1.07 in left painful knees and 1.18 in right knees without pain and 1.04 in left knees without pain. Their measurements were made while subjects were standing. The present study found the average patella to patellar tendon ratios were 1.1 for both the right and left knees. The measurements were made with the subject sitting and the knee at 30 degrees of flexion. McConnell (1986) reported that patella alta is present when the length of the patellar tendon is 20% greater than the height of the patella.

Iliotibial band tightness was indicated simply as "positive" or "negative" in two studies (Winslow and Yoder, 1995; and Puniello, 1993). Winslow and Yoder (1995) considered iliotibial tightness positive if during the Ober's test the leg did not adduct beyond the midline of the subject's body. Puniello (1993) also rated the iliotibial band positive for tightness if the hip could not adduct beyond neutral. Measurements in this study were recorded as the number of centimeters from the exam table to the medial condyle (distance off the exam table) and therefore cannot be compared without also knowing distance from table surface to the subject's midline.

CHAPTER VI

CONCLUSION

Results of this study revealed no significant relationship between the level of sports participation and knee pain/pathology in this group of female adolescents. The anatomical measurements were similar to values reported in previous studies and were within normal ranges. Based upon these results, the strongest indicators for knee pain were decreased right hamstring flexibility, a greater Q angle measurement and right iliotibial band tightness. None of the correlations were statistically significant at the .05 level of significance. Based on the results of this study it does not appear that a screening process for the identification of anatomical factors relating to knee pain/pathology is justified. However, it is recommended that efforts be made to teach female students correct methods of acquiring hamstring and iliotibial band flexibility. Factors present in some young females that are easily identifiable (e.g., high or fallen arches, high riding patella, and varus and valgus knees) may need intervention to prevent future knee pain. An abnormal Q angle is affected by numerous other factors such as tibial or hip rotation and is not easily corrected. Further studies should continue to investigate the relationship of other anatomical factors to knee pain and should include subjects with painful knees and subjects without knee pain. Muscle imbalance and proprioceptive differences are also variables that need to be explored.

This study was performed by a single investigator. Further study with multiple examiners and a larger sample size could help control for any experimenter bias and random error. Intertester and intratester reliability studies would then be indicated. The data collected does provide further information about the relationship between knee pain/pathology and sports participation. The study also has provided additional information regarding the relationship between anatomical measurements of the lower extremities and knee pain/pathology. The data give additional mean values and ranges for the lower extremity measurements.

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APPENDIX A

CONSENT FORMS

STUDENT INFORMED CONSENT

Dear Student:

I am currently enrolled in the Masters Program in Health Studies at Portland State University. My curriculum includes a research project and I have chosen to investigate "The Female Adolescent Knee". You are invited to participate in the study. The information that will be requested includes completion of a questionnaire concerning any symptoms or pain and discomfort you may have in your knee(s). You will also be requested to answer questions concerning the amount of sports training and competition in which you participate. Several noninvasive measurements of your legs and feet will also be involved. These measurements require only the identification of several bony landmarks of the lower extremities. The only inconvenience for you will be the time that is required to complete the questionnaire and have the measurements made which will be approximately 20 to 30 minutes. The risks are very minimal and require only simple movements of the lower extremities.

The purpose of the study is to obtain information on the relationship between various measurements in the hip, knee and foot, and the intensity of sports participation and how they relate to knee problems. The only benefit of your participation in the study is to increase knowledge and benefit others in the future. There will be no other compensation.

All data and identification of the subjects will remain confidential. Names will not be put on data sheets and files will be kept locked in a secure location. You have the choice to discontinue the experiment at any time if you have any distress that would go beyond what would normally be expected or if you feel uncomfortable with the primary investigator. Withdrawal from the study has no consequence. You may ask Patti Seely any questions about the study.

If you have any questions concerning the study, please contact me at 452-1341.

I have decided to participate in the study "The Female Adolescent Knee". My signature indicates that I have read the information above and have decided to participate. I realize that I may withdraw without prejudice or consequence at any time after signing this form should I decide to do so.

Student's Name ____

Student's Signature____

Witness Signature______________________________Date:_____________

If you have any concerns or questions about this study, please contact the Chair of the Human Subjects Research Review Committee, Research and Sponsored Grants, 105 Neuberger Hall, Portland State University, (503) 725-3417.

PARENT/GUARDIAN INFORMED CONSENT

Dear Parent/Guardian:

I am currently enrolled in the Masters Program in Health Studies at Portland State University. My curriculum includes a research project and I have chosen to investigate "The Female Adolescent Knee". Your Daughter is invited to participate in the study. The information that will be requested includes completion of a questionnaire concerning any symptoms or pain and discomfort your daughter may have in her knee(s). She will also be requested to answer questions concerning the amount of sports training and competition in which she participates. Several noninvasive measurements of her legs and feet will also be involved. These measurements require only the identification of several bony landmarks of the lower extremities. The only inconvenience for her will be the time that is required to complete the questionnaire and have the measurements made which will be approximately 20 to 30 minutes. The risks are very minimal and require only simple movements of the lower extremities.

The purpose of the study is to obtain information on the relationship between various measurements in the hip, knee and foot, and the intensity of sports participation and how they relate to knee problems. The only benefit of her participation in the study is to increase knowledge and benefit others in the future. There will be no other compensation.

All data and identification of the subjects will remain confidential. Names will not be put on data sheets and files will be kept locked in a secure location. She has the choice to discontinue the experiment at any time if she has any distress that would go beyond what would normally be expected or if she feels uncomfortable with the primary investigator. Withdrawal from the study has no consequence. You or your daughter may ask Patti Seely any questions about the study.

If you have any questions concerning the study, please contact me at 452-1341.

I have decided to allow my daughter to participate in the study "The Female Adolescent Knee". My signature indicates that I have read the information above and have decided to allow participation. I realize that she may withdraw without prejudice or consequence at any time after signing this form should she decide to do so.

Child's Name____

Parent/Guardian Signature_________________________________

Witness Signature___________________________ Date__________

If you have any concerns or questions about this study, please contact the Chair of the Human Subjects Research Review Committee, Research and Sponsored Grants, 105 Neuberger Hall, Portland State University, (503) 725-3417.

APPENDIX B

QUESTIONNAIRE

QUESTIONNAIRE

KNEE PAIN AND SYMPTOMS

Instructions: Please answer the following questions as honestly as possible. Please indicate how much or how often you experience the following. A rating of 5 means you experience or feel what is described all the time. A rating of 0 means you never feel or experience what is described. Indicate how much you experience what is described by marking along the line somewhere between never and always or at the lines for never and always.

Thinking about the past two months:

	Never	Sometimes	Always
1. Have you had pain around your knee(s)?	0___	___	___5
2. Have you had knee pain when you bend your knee(s) a little while standing?	___	___	___
3. Have you had swelling in the knee(s)?	___	___	___
4. Have you had a sensation of the knee(s) giving way? A feeling that your legs are weak and can't support you?	___	___	___
5. Have you had knee pain upon rising after sitting for a long time?	___	___	___
6. Have you had clicking when you bend straighten your knee(s)?	___	___	___
7. Have you felt or heard grinding when you go up or down stairs?	___	___	___
8. Have your knees hurt after running?	___	___	___
9. Have your knees hurt after other types of exercise?	___	___	___

10. Have you had treatment for any knee problems in the past? Yes____ No____
11. Have you had any trauma/ injuries to the lower extremities? Yes____ No____

____

____

How many years have you participated in organized sports programs?____

INTENSITY OF SPORTS PARTICIPATION

Circle one number for each category.

1. How many days per week do you participate in organized sports practice?

FALL	**WINTER**	**SPRING**	**SUMMER**
1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

2. How many days per week do you participate in organized sports games or competition?

FALL	**WINTER**	**SPRING**	**SUMMER**
1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

3. How many days per week do you do some type of exercise program on your own, such as P. E. Class, swimming, bicycling, roller blading, etc?

FALL	**WINTER**	**SPRING**	**SUMMER**
1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

4. Please explain the activities exercise or sport for each season.

FALL	**WINTER**	**SPRING**	**SUMMER**
________	________	________	________
________	________	________	________
________	________	________	________

APPENDIX C

RAW DATA

APPENDIX C

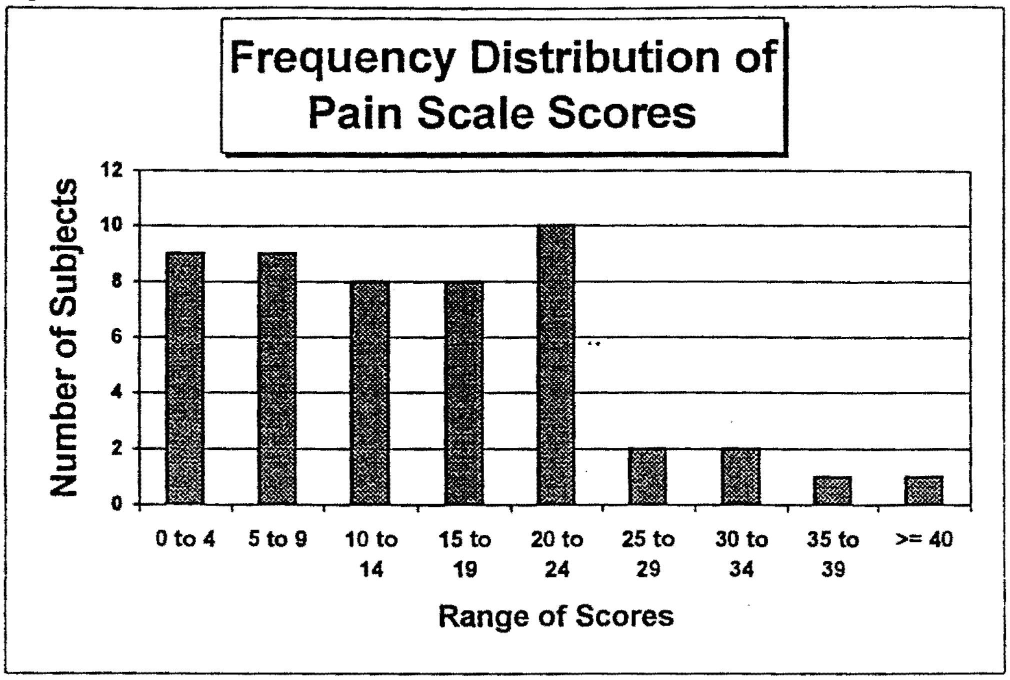
RAW DATA

Subject	Pain Scale	Sport Part.	Q Angle		- Into Hyperextension Knee Hyperextension		IT Band		Hamstring Flexibility		Patella Alta		Calcaneal Position	
			R	L	R	L	R	L	R	L	R	L	R	L
1	15.5	18	14	14	2	-1	3	6	-24	-18	0.7	0.8	10	20
2	31.5	52	12	17	10	10	11	8.5	-15	-23	1.4	1.37	20	12
3	11.5	25	18	17	-4	0	12	10	-15	-20	0.96	1.13	10	10
4	5	54	12	5	-5	-3	21	16	-20	-30	1.2	0.7	8	0
5	20	26	22	18	-15	-16	0	0	-48	-14	1.07	1.05	8	10
6	15.5	52	20	18	-2	-2	3	3	-28	-28	1.14	1.07	2	5
7	2	18	19	20	-3	-4	4.5	8	-38	-35	1.4	1.15	10	5
8	10.5	25	11	13	-8	-10	0.5	1.5	0	0	1.06	1.04	10	5
9	21.5	17	12	8	-5	-5	3	4	-20	-17	1.04	1.42	4	0
10	7	43	12	12	5	5	0	0	-18	-19	0.9	0.83	8	10
11	11	19	8	13	3	4	8	7	-18	-19	1.3	1.14	10	13
12	19	30	11	10	9	4	10	10	-22	-30	1.2	1.04	5	10
13	20	31	10	20	-10	-5	3	4	-12	-10	1.2	1.15	7	10
14	41	29	15	14	-5	-5	5	5	-20	-25	1.24	1.19	3	10
15	1.5	36	12	10	0	2	5.5	5	-45	-40	1.43	1.09	8	10
16	6	18	15	20	-5	-4	9	8	-15	-22	0.95	0.95	5	8
17	20.5	44	10	12	-8	-4	5	7	-28	-30	1	0.94	10	10
18	26	43	15	10	-5	-8	7.5	7	-15	-12	1.04	1.06	3	0
19	17	22	18	12	5	5	5.5	6	-15	-18	0.8	0.75	0	9
20	6	30	15	20	-8	2	0	0	-30	-33	1.23	1.16	8	5
21	6	84	12	8	8	-5	0	1	-30	-33	1.25	1.2	6	10
22	27	12	18	15	5	5	0	0	-35	-35	1	0.84	5	5
23	0	30	12	16	-3	2	5.5	4	-28	-20	1.375	1.04	5	2
24	23	66	14	13	-2	-5	8	8	-15	-25	1.07	1.25	5	0
25	36	46	15	17	0	0	4	10	-12	-30	1.04	1	0	0
26	17.5	47	12	14	-3	-3	11	9	-15	-13	1	0.83	3	5
27	0	26	10	12	10	5	18	7	-25	-25	1	1	10	10
28	5.5	41	11	10	3	8	8	8.5	-23	-30	0.93	0.93	3	8
29	15	44	10	12	2	2	7.5	6.5	-10	-12	1.04	0.83	2	2
30	5	35	8	8	5	3	16	14	-30	-28	1.2	0.95	0	0
31	24	51	12	14	5	8	1	1	-20	-22	1.1	1	5	10
32	4	22	8	8			2	2	-20	-22	1	1	10	8
33	21	43	8	8	6	6	10	13	-30	-32	1	0.83	5	10
34	8.5	27	10	10	8	10	4	10	-45	-45	0.7	0.72	8	8
35	3	22	13	12	5	5	10	5	-25	-10	1.25	1.25	3	3
36	14.5	26	6	8	-11	-13	8	8	-28	-30	1	1.25	8	10
37	10	42	8	8	3	3	12	6	-35	-40	1.2	1.2	8	11
38	0.5	56	5	5	0	0	15	13	-28	-18	1	1.25	10	10
39	2.5	56	8	8	0	0	15	15	-20	-22	0.9	1	15	12
40	21	33	15	15	-5	-3	15	20	-25	-26	0.9	0.83	0	0
41	9.5	49	15	15	-5	-8	18	14	-8	-8	1.1	1.25	15	12
42	17.5	32	10	12	2	2	4	8	-8	-12	1.12	1.12	7	10
43	30	33	12	20	5	5	14	14	-12	-20	1.5	1.25	5	8
44	3.5	15	18	18	5	5	13	13	-35	-30	1.25	1.43	3	3
45	5	23	10	20	-10	-10	18	22	-38	-32	1.1	1.6	10	10
46	12.5	19	15	20	10	10	0	0	0	0	1.25	1.25	10	10
47	18	17	17	20	0	0	12	12	-35	-26	1.3	1.25	5	10
48	12	30	18	20	0	-5	0	0	0	-5	1	1.25	5	5
49	20	43	15	10	0	0	2.5	0	0	0	1	1	10	10
50	13	20	10	8	-8	-8	11	10	-10	-8	1.25	1.25	3	3

APPENDIX D

LIST OF FIGURES

Figure 1



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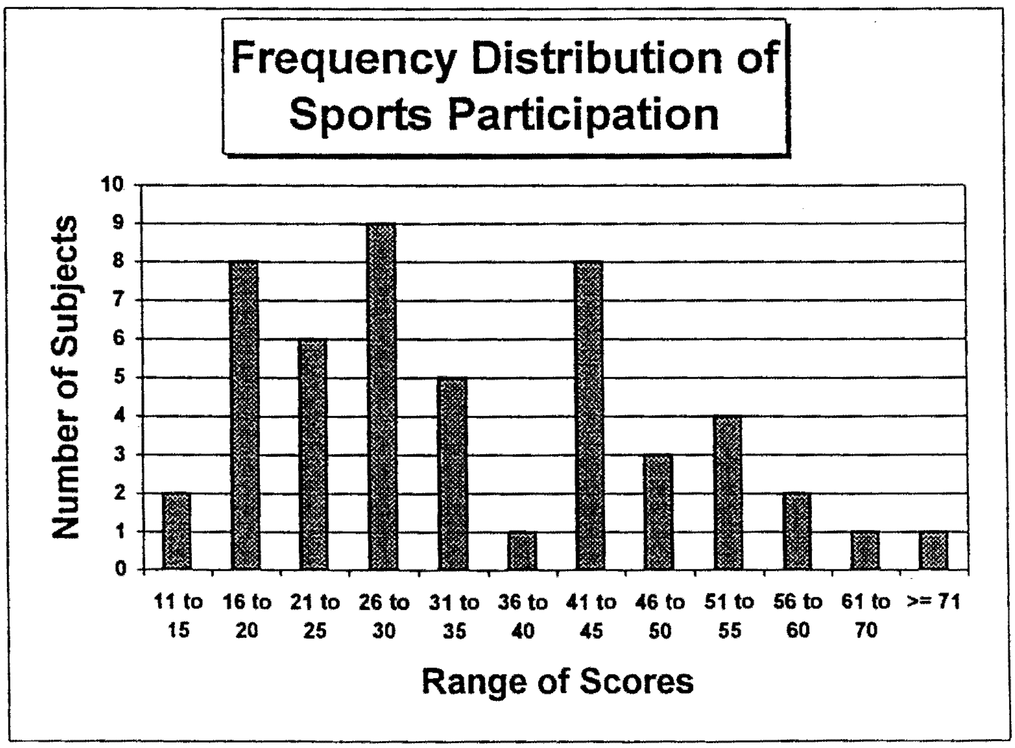

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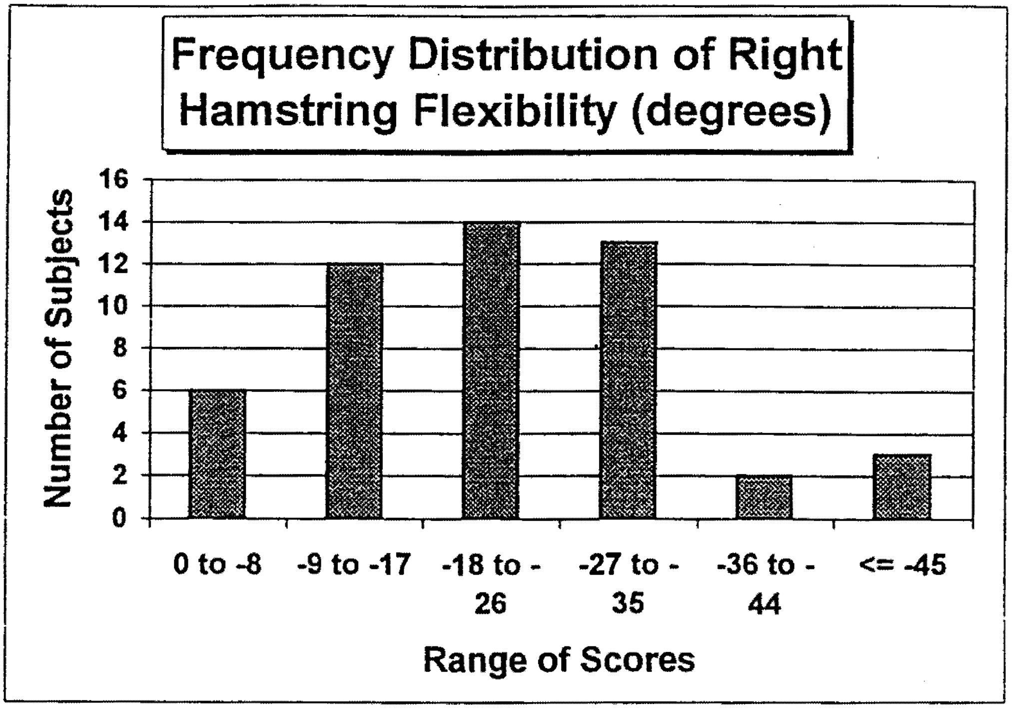

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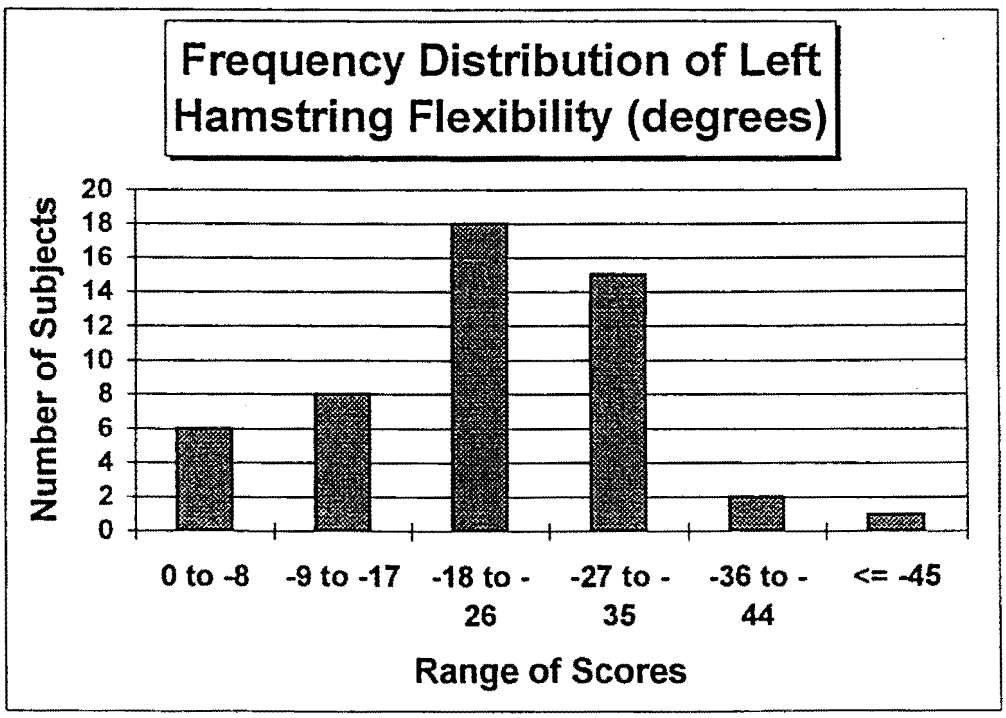

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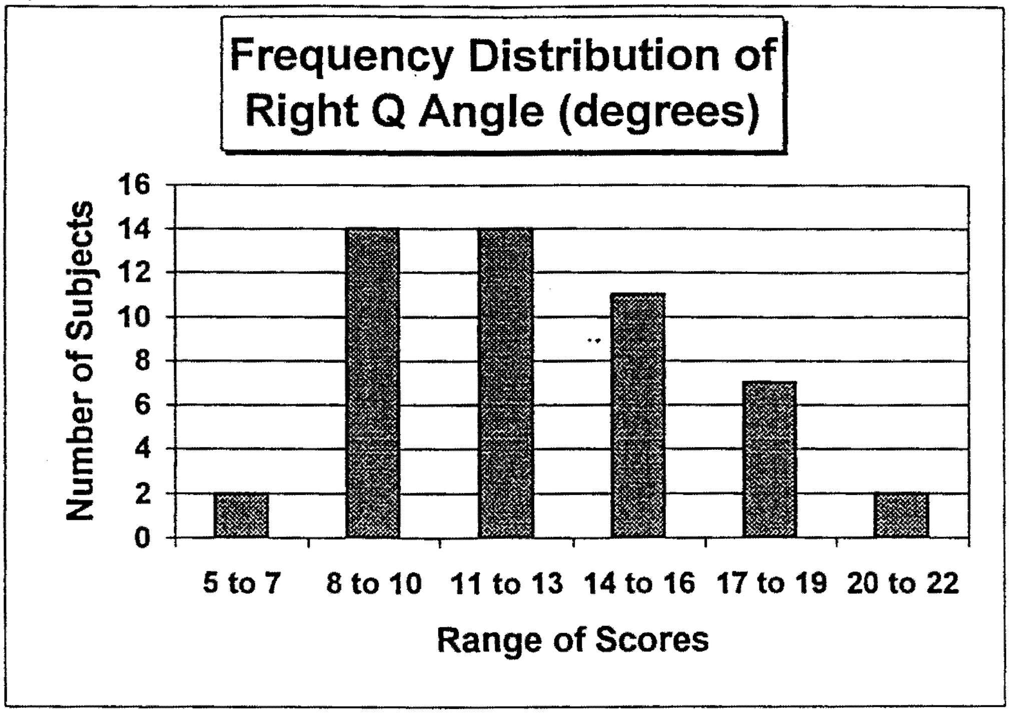

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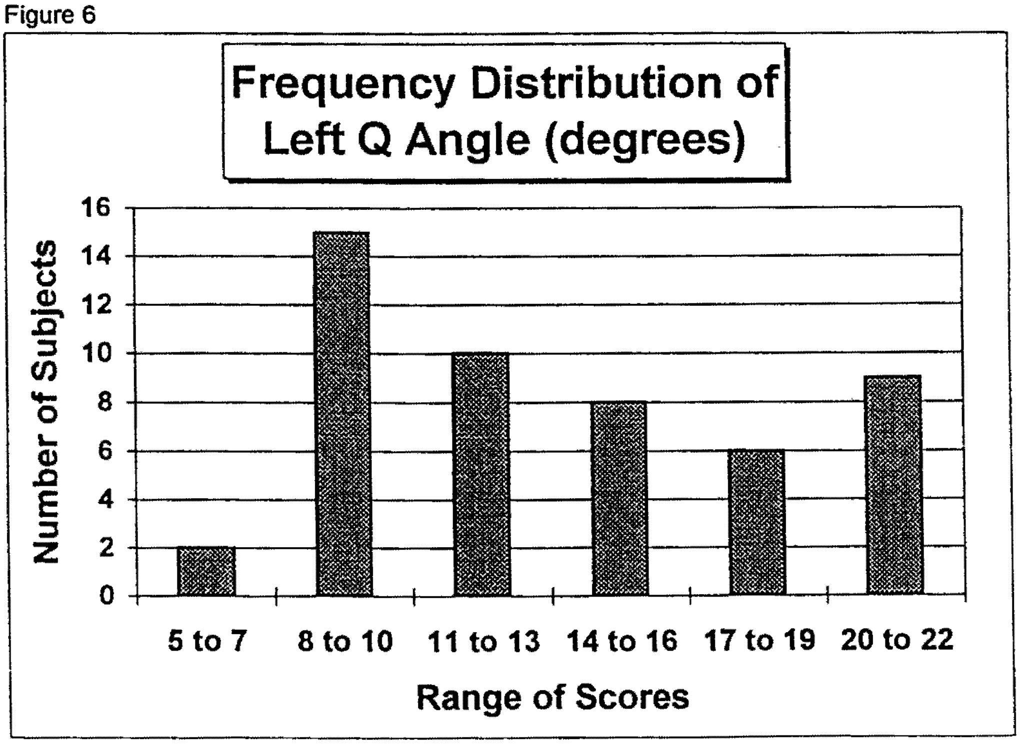

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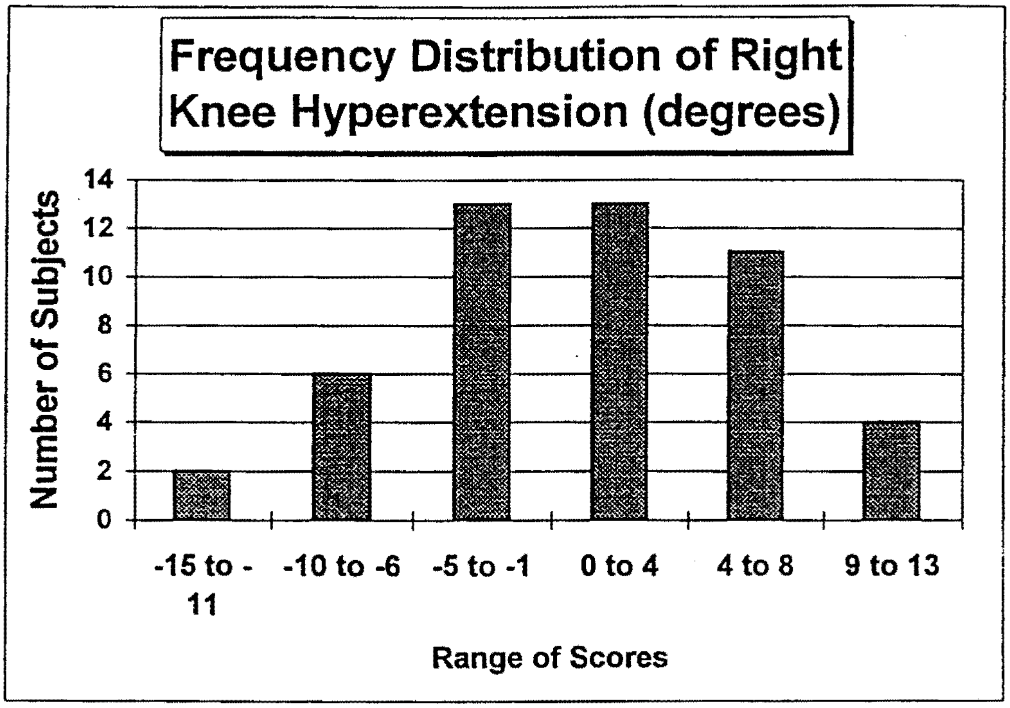

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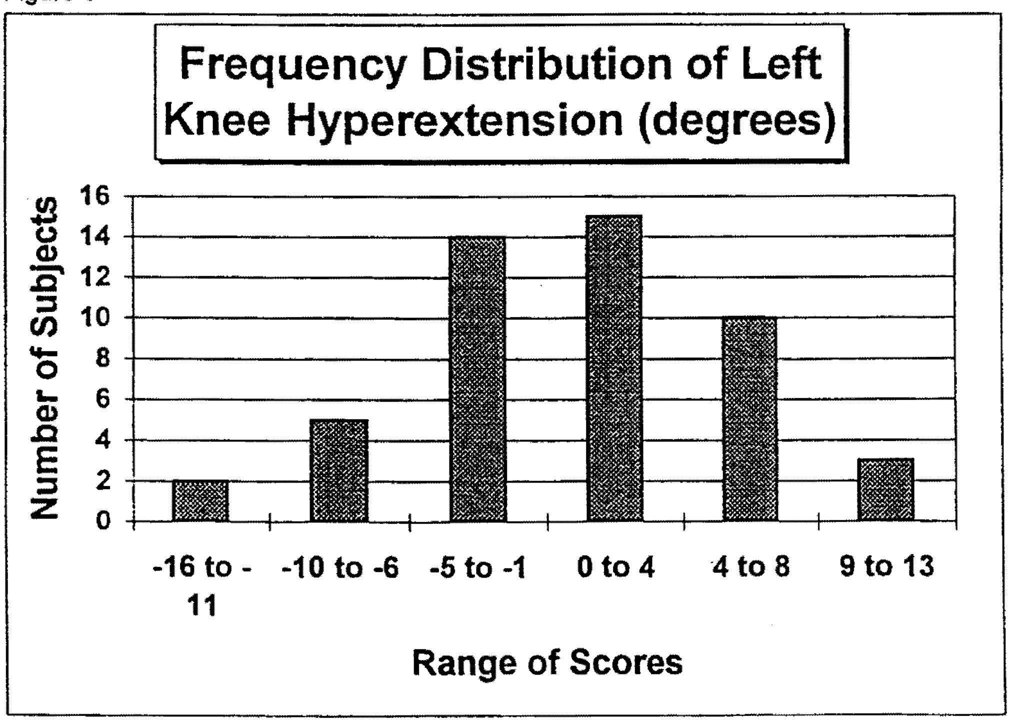

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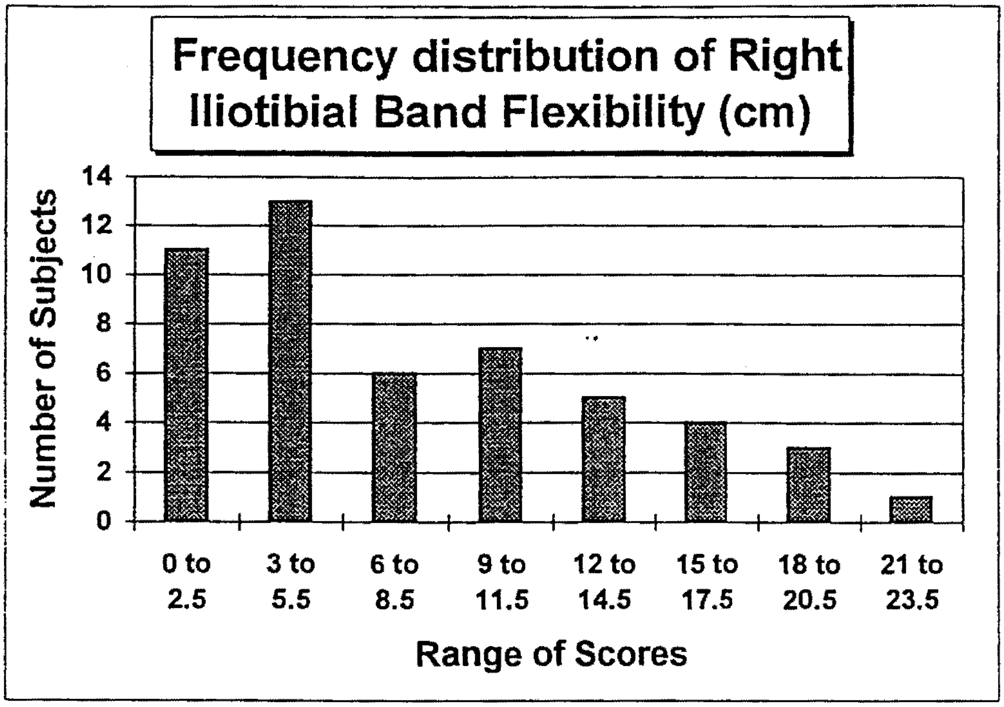

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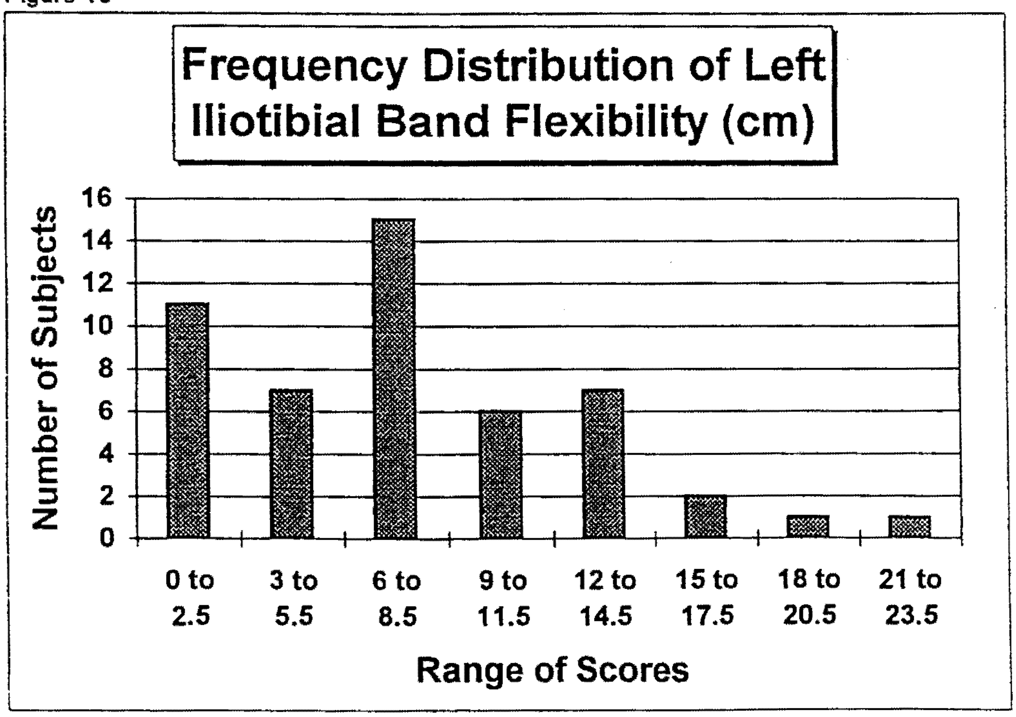

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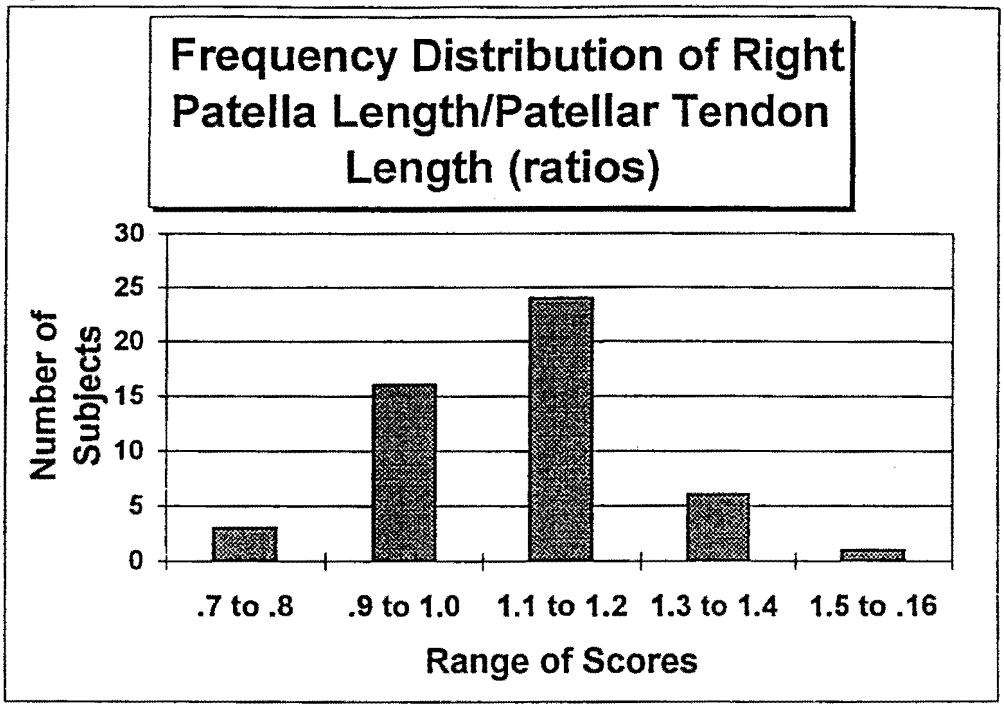

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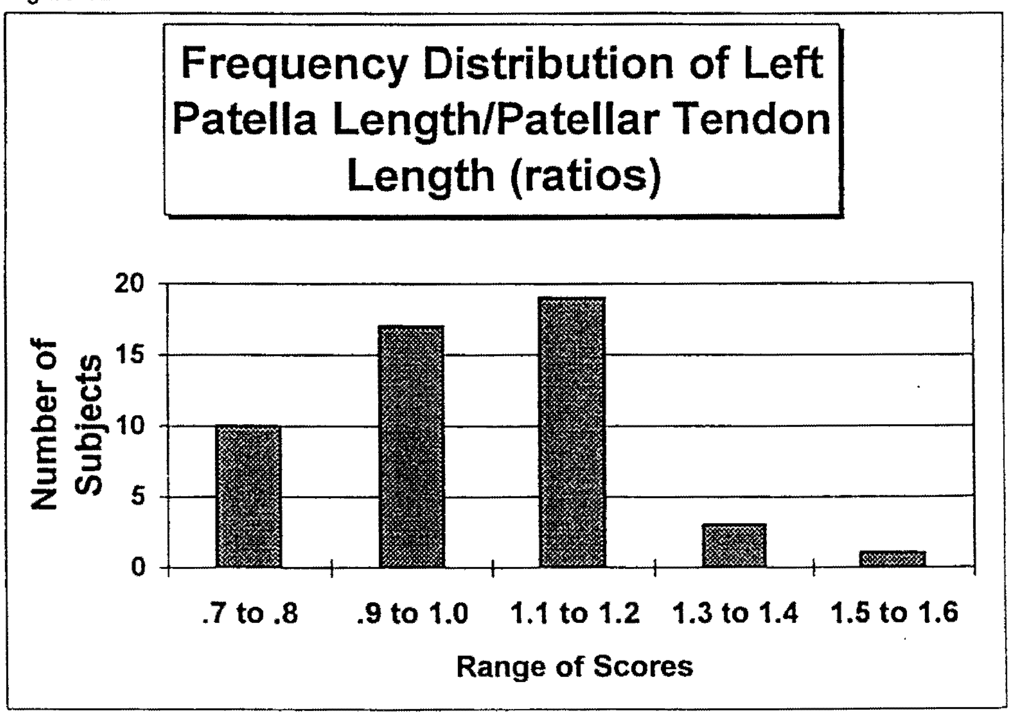

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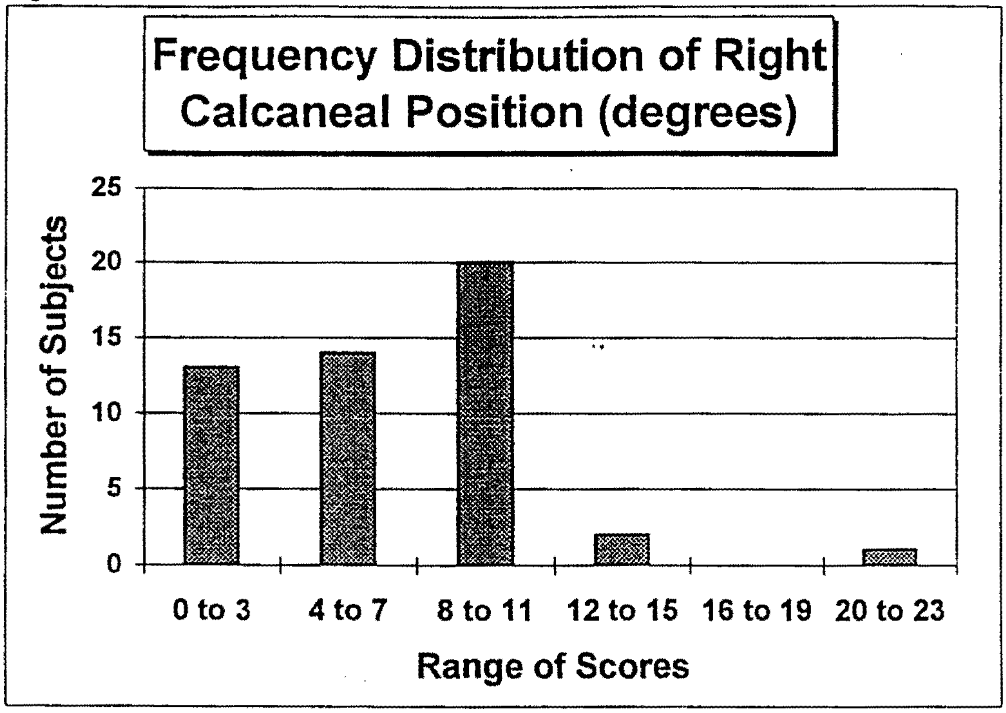
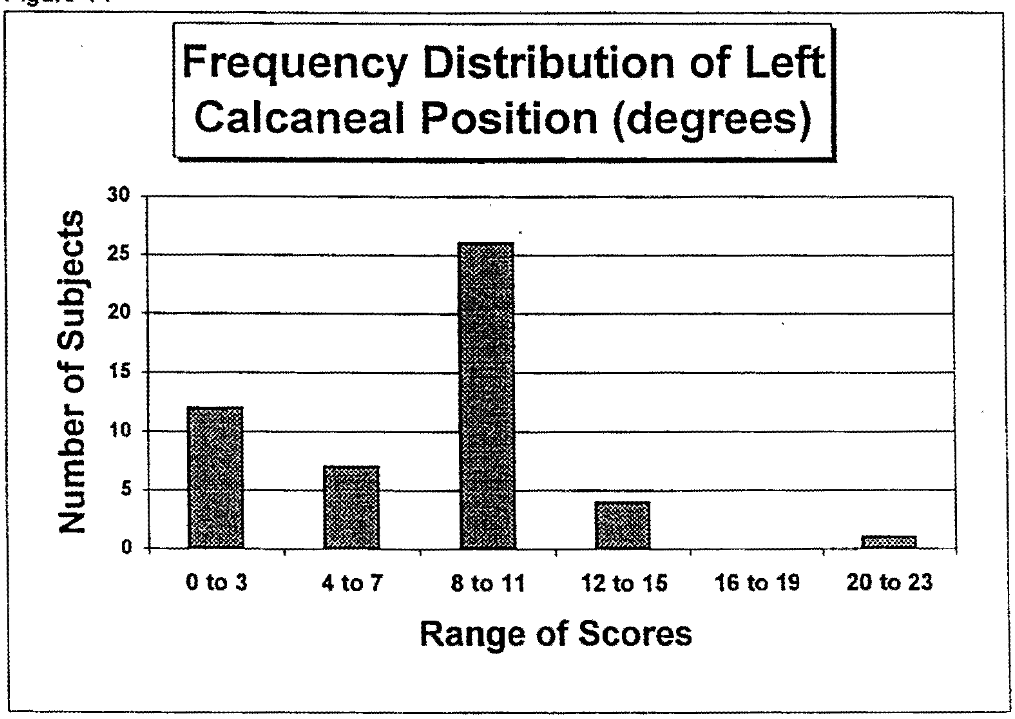


Figure 14



APPENDIX E

INTERCORRELATION MATRIX

APPENDIX D

INTERCORRELATION MATRIX

	Pain Scale	Sport Part	Q Angle R	Q Angle L	HyperextR	HyperextL	IT Band R	IT Band L	HamFlexR	HamFlexL	Pat/TenR	Pat/TenL	Calcan R	Calcan L
Pain Scale														
Sport Part.	0.07 p=.64													
Q Angle R	0.24 p = 1	0.22 p = 12												
Q Angle L	0.19 p = .18	0.36 p = .01	0.63 p = .00											
HyperextR	-0.05 p = .75	0.12 p = .41	-0.14 p = .35	-0.16 p = .27										
Hyperext L	-0.06 p = .69	0.02 p = .88	-0.145 p = .32	-0.04 p = .79	0.852 p = .00									
IT Band R	-0.23 p = .11	0.11 p = .46	-0.303 p = .03	-0.196 p = .17	0.02 p = .89	0.005 p = .97								
IT Band L	-0.08 p = .57	0.06 p = .66	-0.267 p = .06	0.01 p = .94	0.067 p = .65	-0.05 p = 74	0.863 p = .00							
HamFlexR	0.27 p = .05	0.103 p = 48	-0.03 p = .84	0.07 p = 66	0.034 p = 8	-0.015 p = .92	-0.096 p = .51	-0.169 p = .24						
HamFlexL	0.1 p = 46	0.1 p = .49	0.11 p = 46	0.13 p = 36	-0.164 p = .26	-0.23 p = 12	-0.165 p = .25	-0.283 p = .05	0.776 p = .00					
Pat/Ten R	0.01 p = .96	0.005 p = .97	0.035 p = .77	0.26 p = 07	0.04 p = .79	0.06 p = 69	0.113 p = 44	0.007 p = 96	-0.076 p = .6	-0.051 p = 72				
Pat/Ten L	-0.01 p = .95	0.1 p = .49	0.012 p = .94	0.3 p = .04	-0.163 p = .26	-0.24 p = .09	0.122 p = .4	0.08 p = .56	0.01 p = .5	0.12 p = .4	0.54 p = .00			
Calcan R	-0.22 p = .13	0.102 p = .49	-0.21 p = .15	0.014 p = .92	0.001 p = .99	-0.003 p = .98	0.09 p = .53	-0.016 p = .91	0.038 p = 79	0.077 p = .59	0.065 p = .65	0.234 p = 102		
Calcan L	-0.04 p = .8	0.04 p = 77	-0.167 p = .25	0.045 p = .76	0.182 p = 21	0.134 p = .34	-0.08 p = 58	-0.106 p = 46	-0.07 p = .62	-0.0008 p = .9	-0.137 p = 34	0.035 p = 81	0.603 p = 00	