Genu valgum : can observable or symptomatic changes occur with an exercise protocol in collegiate women?
by Jaime Erin McCafferty

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Health and Human Development
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Abstract:
Genu valgum, or “knock-knees”, is a structural deformity that results in knee adduction. Genu valgum and increased quadriceps (Q) angle are synonymous and lead to an increase in lower extremity injuries and painful symptoms. Women typically have larger Q angles than men, and are therefore at an increased risk for injury. There is no known exercise protocol to correct the genu valgum deformity. The primary goal of this study was to implement an exercise protocol in collegiate women who have genu valgum and measure changes. The secondary goal was to decrease symptomatic afflictions associated with genu valgum.

Eleven collegiate women volunteered to participate in the study and were divided into either a treatment (n=6) or control (n=5) group. The treatment group participated in a six-week exercise protocol meant to strengthen the hip flexors, internal and external rotators, hip abductors and adductors, and knee flexors and extensors. Lower extremity digital photographs were taken of the subjects prior to the study and following each week of treatment. Tibial Femoral Angle (TFA) and Q angle were the variables measured from the photographs. Strength measures of the targeted muscles were taken prior to the study, following week three, and at the conclusion using a Manual Muscle Tester (MMT). Subjective data was documented in the form of Visual Analog Scales (VAS).

The results of the study noted decrease in the treatment group Q angle, with more change occurring in the right leg. The TFA also improved in the treatment group, and more change was present in the right leg as well. Strength increased in the subjects performing the exercise protocol, and those who completed the protocol reported a decrease in symptoms.

In conclusion, it is reasonable to expect that a longer exercise protocol would yield greater changes in Q angle and TFA in collegiate women with genu valgum. It is likely that the strength gain experienced by the subjects was the factor in the decrease of Q angle, TFA, and symptoms. Therefore, this protocol proved to be a beginning step to correcting the appearance of genu valgum and decreasing associated symptoms in collegiate women.

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date 17 April 2002

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ABSTRACT

Genu valgum, or "knock-knees", is a structural deformity that results in knee adduction. Genu valgum and increased quadriceps (Q) angle are synonymous and lead to an increase in lower extremity injuries and painful symptoms. Women typically have larger Q angles than men, and are therefore at an increased risk for injury. There is no known exercise protocol to correct the genu valgum deformity. The primary goal of this study was to implement an exercise protocol in collegiate women who have genu valgum and measure changes. The secondary goal was to decrease symptomatic afflictions associated with genu valgum.

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INTRODUCTION

Statement of the Problem

One of the most common deformities in the knee joint is genu valgum, and has been cited to be more common among women (Hoppenfeld, 1976 & Livingston, 1998). Genu valgum, or "knock-knees" is defined as a structural abnormality of the alignment of the femur on the tibia (Hoppenfeld, 1976). It is characterized by lateral rotation of the femurs, hyperextension of the knees, and pronation of the feet, and all of these factors contribute to adduction of the knees (Kendall, McCreary, & Provance, 1993) (Figure 1).

A correlation between genu valgum and an increased quadriceps (Q) angle has been observed. In addition to an increased Q angle, flat feet, patellofemoral pain, thigh and hip muscular weakness, medial joint stress, medial joint instability, and an increased risk for anterior cruciate ligament (ACL) injuries have been discussed in conjunction with genu valgum (Starkey & Ryan, 1996 and Arnheim & Prentice, 2000). Byl, Cole, and Livingston (2000) stated their investigation supported the common observation that women, on average, have larger Q angles than men do. Lathinghouse and Trimble (2000) also stated that women have consistently been found to have larger Q angles than men, and are more often affected by patellofemoral problems. The National Collegiate Athletic Association (NCAA) reported data indicating collegiate women basketball players were four times more likely to sustain an ACL injury than their male counterparts (Moeller & Lamb, 1997).

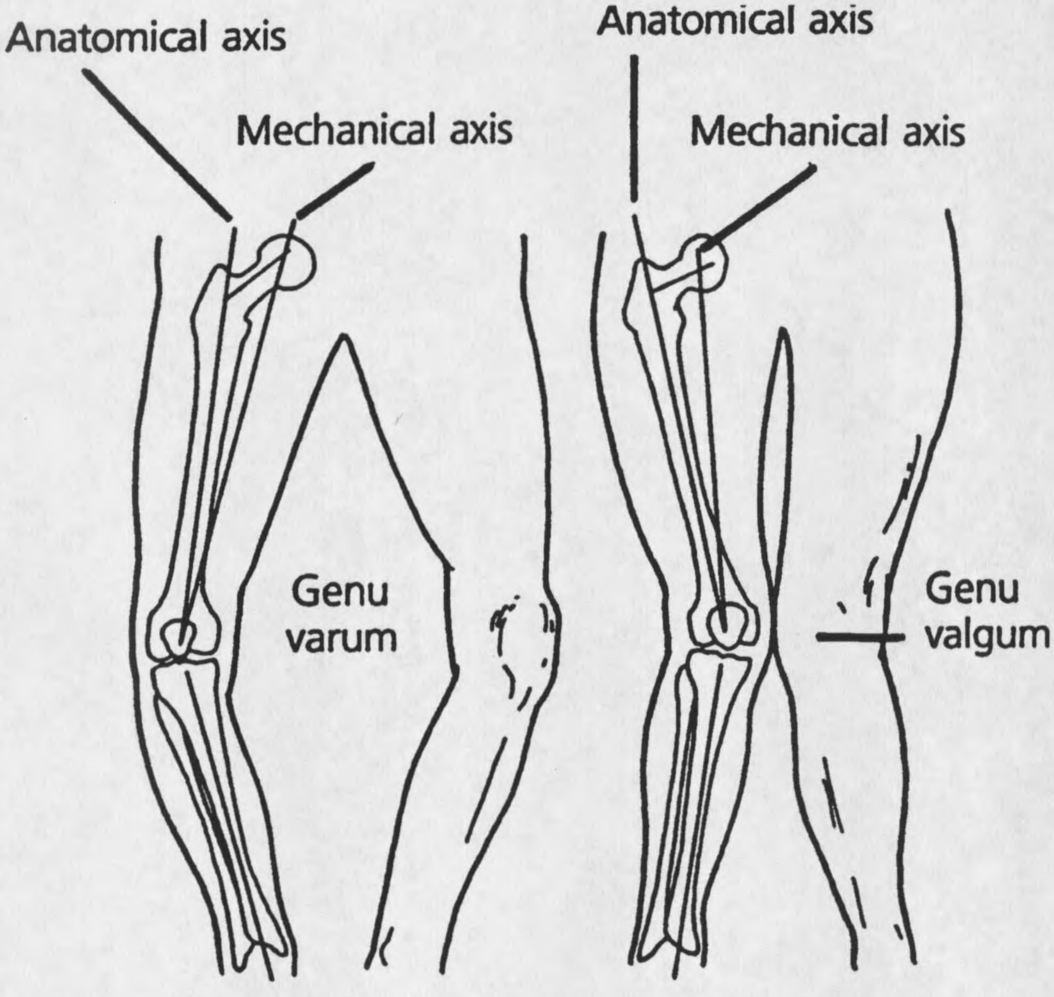

Figure 1. Anatomical and Mechanical Axes of the Lower Extremity.

Current treatment for the genu valgum deformity ranges from physical therapy to surgery. It is the purpose of this study to explore a physical therapy program to correct genu valgum in collegiate women, and it is believed by the researcher that a six week individualized exercise program will decrease the visual appearance of genu valgum in the subjects studied. The exercise program will consist of exercises concentrating on strengthening hip flexors, hip abductors and adductors, hip internal and external rotators, hamstring muscle group, and quadriceps muscle group. Within the reviewed literature, it is stated that muscular weakness may be present in people with genu valgum (Kendall et al., 1993). Weakness of the medial hamstring muscles leads to a decrease in stability of the medial knee joint, and because of this weakness, a genu valgum position of the knee is allowed and tendency for lateral rotation of the leg on the femur is present (Kendall et al., 1993). Kreighbaum and Barthels (1996) stated that strengthening should take place in order to correct this malalignment. On the premise that exercise should be implemented to correct the genu valgum deformity, a study should be conducted to determine whether exercises could provide an anatomical change in the deformity. The physical therapy option for treating genu valgum should be researched in order to arrive at an alternative to surgery, which may have complications, unsuccessful results, and can be costly. All other treatments, excluding surgery, do not attempt to change the biomechanics of genu valgum, but to provide symptomatic relief. It is the intent of this study to determine if exercise can correct the anatomical deformity of genu valgum. Any symptomatic relief that occurs as a result of the exercise protocol is secondary to the purpose of the study.

Primary Hypothesis

It is hypothesized that the group of subjects who perform the exercise protocol (treatment group) will have a decrease in the anatomical appearance of genu valgum, whereas the control group will have no change in the appearance of genu valgum.

$$H_O: \triangle M_C = \triangle M_T = 0$$

$$H_A: \triangle M_C = 0, \text{ Pre } M_T > \text{Post } M_T$$

The notations of M_C and M_T are the mean population values for the appearance of genu valgum in the control and treatment groups, respectively. A decrease in anatomical appearance correlates with a decrease in the quadriceps (Q) angle measurement and an increase in the tibial femoral angle (TFA). The TFA will be closer to 180° than the baseline measurement.

Secondary Hypothesis

It is hypothesized that there may, in fact, be no change in symptoms of genu valgum in the treatment group following the treatment protocol.

$$H_O: \triangle M_{SC} = \triangle M_{ST} = 0$$

$$H_A: \triangle M_{SC} = 0, \text{ Pre } M_{ST} > \text{Post } M_{ST}$$

The notations of M_{SC} and M_{ST} are the mean population values for the symptoms of genu valgum in the control and treatment groups, respectively. It is possible that symptoms of genu valgum may be alleviated without a decrease in the degree of deformity. Symptoms of genu valgum generally include pain of the hip, medial and lateral knee, lower legs, ankles, and feet. The visual analog scales (VAS) in the signs and symptoms questionnaires will address symptomatic relief that may result from the treatment for genu valgum. The VAS measurements will be used to gain subjective information indicating any change in symptomatic problems associated with genu valgum.

Assumptions

It is assumed that all subjects will adhere to the guidelines of the study and will comply with the protocols set by the researcher. Also, an assumption is made regarding genu valgum. It is assumed that every day activities do not affect the degree of deformity, but do have an impact by increasing symptoms.

Limitations

This study is dependent on those who volunteer for the study, and this may result in difficulties gaining an adequate number of subjects. The degree of genu valgum is expected to vary within the subjects, and it is also expected that differences will be present in signs, symptoms, and fitness habits. All subjects will not be identical. The design of the study implements a short duration of intervention. It is acknowledged that this short duration may only yield minor results.

Delimitations

The method of gaining the subjects is not a true random sample, since it only draws upon people who volunteer from Montana State University in Bozeman, Montana. The findings of this study can only be applied to collegiate women.

Operational Definitions

Control Group: A group of subjects who will not participate in the exercise protocol.

Genu valgum: Knock-knees; a deformity of the knee where the femur and tibia are angled inward.

Quadriceps (Q) angle: An angle formed by the intersection of a line from the anterior superior iliac spine to the midpatella and another line from midpatella to the tibial tuberosity; an angle of 15° or less is considered normal (Booher & Thibodeau, 1994).

Tibial femoral angle (TFA): The angle formed by the anterior view of the tibial shaft and the femoral shaft where the average alignment is 180-195°.

Treatment Group: A group of subjects who will participate in the exercise protocol.

Visual analog scale (VAS): a subjective measure of symptoms associated with genu valgum.

LITERATURE REVIEW

Problems Associated with Genu Valgum

Genu valgum, commonly referred to as "knock-knees", is a structural abnormality that is noted by the alignment of the femur on the tibia. Knock-knees and bowlegs (genu varum) are two of the most common deformities of the knee joint (Hoppenfeld, 1976). Knock-knees result from a combination of factors including lateral rotation of the femurs, hyperextension of the knees, and pronation of the feet. Also, the axis of the knee joint runs oblique to the coronal plane, so combining the axis of the knee joint with hyperextension leads to adduction at the knees, a common trait associated with genu valgum (Kendall, McCreary, & Provance, 1993). Imagine that a line passing through the femoral and tibial shafts ranges from 180-195° in average alignment. An angle less than 180° is considered genu valgum (Starkey & Ryan, 1996). Genu valgum may be observed without diagnostic imaging, although arthritic changes may be noted in roentgenograms. Hoppenfeld (1976) stated that the valgus angle is usually more pronounced in females.

An increase in compressive forces on the lateral tibiofemoral articulating surfaces occurs as a side effect of genu valgum, along with tensile forces on the medial tibiofemoral ligaments (Starkey & Ryan, 1996). Lateral tracking of the patella, compressive forces of the lateral facet, and stretching of the medial patellar restraints also occur with genu valgum (Starkey & Ryan, 1996). Arnheim and Prentice (2000) stated that pronated feet, chronic tension on medial ligaments of the knee, abnormal compression of the lateral knee, and abnormal tightness of the iliotibial band are commonly associated with genu valgum. Hip external rotator weakness was also noted in people with genu valgum (Arnheim & Prentice, 2000). Weakness of the medial hamstring muscles, the semitendinosus and semimembranosus, leads to a decrease in stability of the medial joint line of the knee (Kendall et al., 1993). This weakness permits a knock-knee position and a tendency toward lateral rotation of the leg on the femur. Shortness of the tensor fasciae latae muscle can be associated with genu valgum as well (Kendall et al., 1993). In an attempt to correct this malalignment, the muscles that stabilize the knee from abduction, the quadriceps in particular, should be strengthened (Kreighbaum & Barthels, 1996).

The angle of inclination is the angular relationship of the femoral head and the femoral shaft, and can be determined roughly by observing the correlation between the femur and the tibia. A decrease in the angle of inclination, coxa vara, may lead to genu valgum or "squinting" patella. "Squinting" patella occurs secondary to an internal rotation of the lower extremity and is noted by medially positioned patellae on the femur. The patellae appear to be looking at one another while the feet are pointed straight ahead (Starkey & Ryan, 1996) (Figure 2).

One of the problems associated with genu valgum is increased tension on the medial ligaments of the knee (Shahane & Bickerstaff, 1997). The medial collateral ligament (MCL) of the knee consists of two parts, with the more superficial portion being the primary inhibitor of external tibial torsion and tibial abduction. This portion

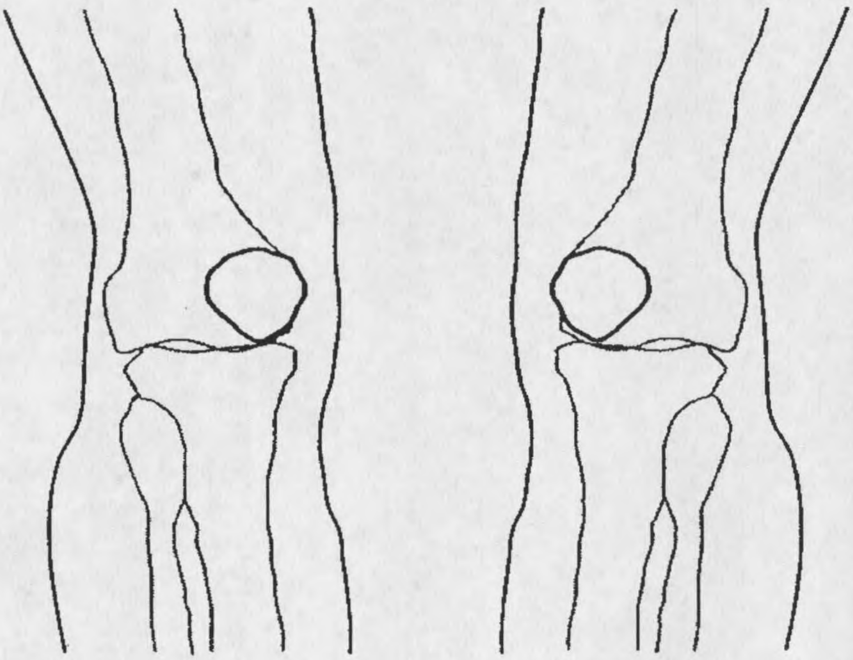

Figure 2. "Squinting" Patella.

of the MCL is strongest from 15-90° of flexion. The deep portion is much weaker and smaller, however, it serves to attach the medial meniscus to the femur and tibia. Excessive genu valgum is likely to impose considerable strain on the proximal femoral attachment of the MCL (Shahane & Bickerstaff, 1997).

Genu valgum is said to be an anatomic risk factor for anterior cruciate ligament (ACL) injuries as well (Griffin et al., 2000). Hip varus, foot pronation, and hip rotation are also said to be a possible anatomic risk factor for ACL injuries. The correlation between ACL injuries and genu valgum has not been fully explored, but is currently under examination (Griffin et al., 2000). In order to visualize the increased stress that femoral rotation can place on the ACL, refer to Figure 3, which presents the anatomy of the knee joint.

Genu valgum is a risk factor for developing patellofemoral pain because the alignment of the tibia on the femur predisposes the patella for malalignment and patellar tracking abnormalities (American Academy of Orthopedic Surgeons, 1991). Genu valgum is said to increase the valgus sector of the knee, therefore increasing the risk for patellar subluxations or dislocations (AAOS, 1991). Also, patellofemoral pain can be associated with pes planus (flat feet), which usually occurs simultaneously with genu valgum. The patellofemoral syndrome is a generalized term and refers to a group of conditions that produce pain beneath or surrounding the patella. Any factor within the knee that disrupts normal patellar tracking can result in inflammation and pain to the undersurface of the patella. Malalignment of the patellofemoral joint may contribute to the development or the severity of pain (Tomsich, Nitz, Threlkeld, & Shapiro, 1996). Since an individual with genu valgum has a tendency towards having excessive pronation of the feet, or "fallen arches", it is likely that heel spurs may begin to form and cause pain. A heel spur is defined as a bony projection on the sole (plantar) region of the calcaneous, or heel bone (Feeny, 1997). The excess bone that is formed when making this bony projection is most likely the result of painful tearing of the plantar fascia on the plantar aspect of the foot.

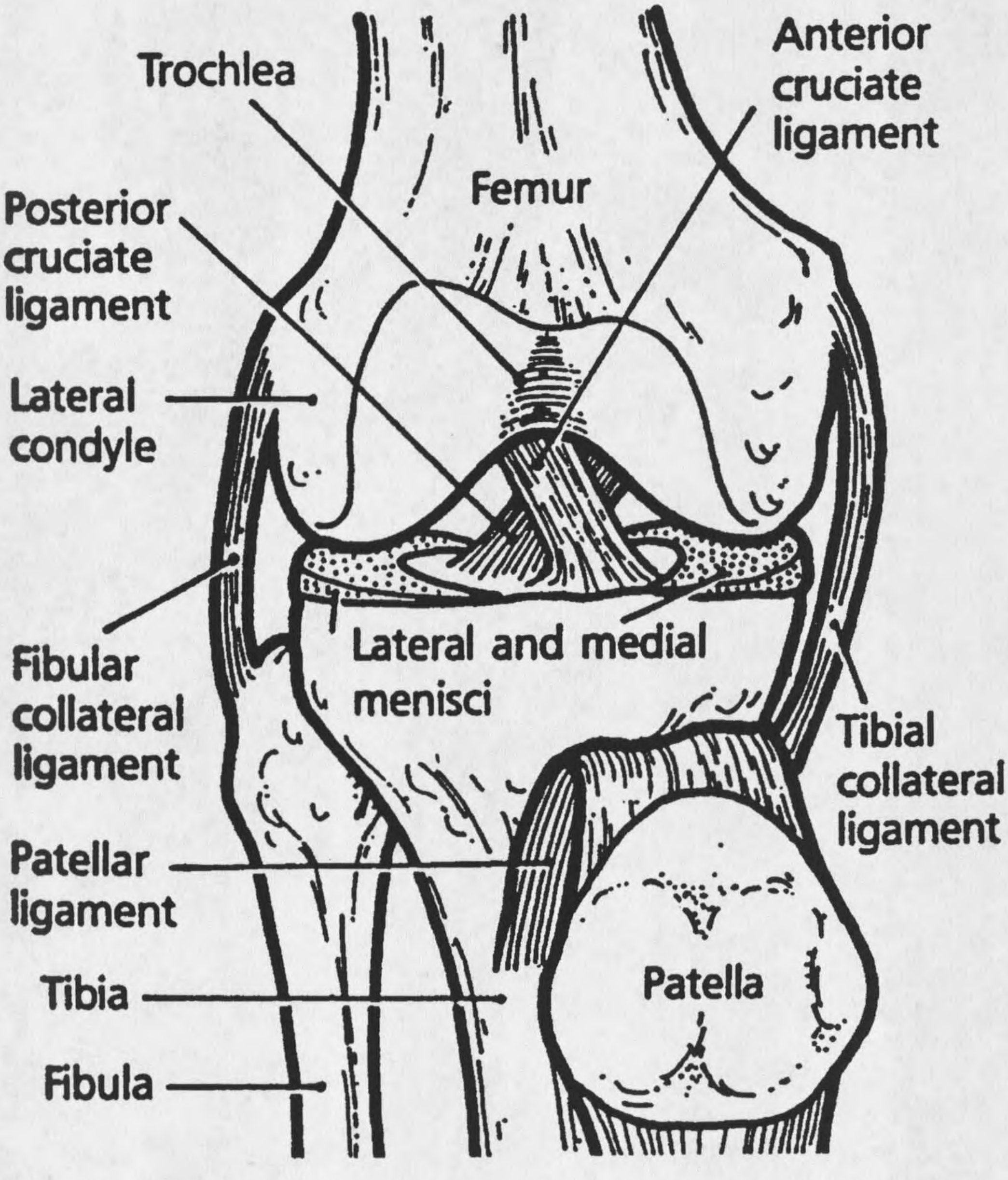

Figure 3. Anatomy of the Knee Joint.

Quadriceps (Q) Angle and Genu Valgum

Liss and Liss (2000), physicians from the Physical Medicine and Rehabilitation Center in Pennsylvania, wrote an informative article regarding patellofemoral pain and the quadriceps (Q) angle. These physicians stated that genu valgum is included within what is known as the malicious malalignment syndrome. The malicious malalignment syndrome is characterized by excessive internal rotation of the hips, genu valgus, pes planus, and an increased Q angle (Liss & Liss, 2000). The Q angle is the angle between a line drawn through the tibia and a line drawn through the anterior superior iliac spine (ASIS) and the patella (Liss & Liss, 2000). An increased Q angle of more than 19° increases the risk of patellofemoral pain, and this increased angle puts additional stress on the knees during the motions of flexion and extension resulting in increased symptoms because of disruption to normal tracking mechanisms (Liss & Liss, 2000).

The present treatment for patellofemoral pain has been strengthening of the quadriceps muscles, which will decrease the initial stress placed on the patella and thus reducing pressure behind the patella and improving patellar tracking. Liss and Liss (2000) stated this method is still controversial. In most studies, simple isometric strengthening results in reduction or elimination of symptoms in 70-80% of patients (Liss & Liss, 2000). Along with exercises, taping of the patella to reduce mechanical problems with patellar tracking has also been implemented (Liss & Liss, 2000). Although this technique can be justified biomechanically, more studies need to be conducted to confirm the actual benefit (Liss & Liss, 2000).

Since the issue of performing quadriceps exercises is still controversial, Boucher, King, Lefebvre, and Pepin (1992) conducted a study to determine whether terminal extension rehabilitation of the vastus medialis was appropriate, and to try to dissociate neuromuscular and mechanical mechanisms that underlie patellofemoral pain syndrome. The vastus medialis oblique (VMO) is the quadriceps muscle that has mainly been focused on in the rehabilitation of patellofemoral pain (Boucher et al., 1992). Traditionally, it is believed that the VMO is the most active in the final degrees of extension (terminal extension) of the knee. Symptoms of patellofemoral pain include diffuse knee pain, loss of motion, swelling, a sensation of instability, and pain with or without activity. Boucher et al. (1992) studied 18 female subjects and placed them into two groups based upon the knee Q angle and a diagnosis of patellofemoral pain syndromes from a physician. The control group was asymptomatic and had a normal Q angle. The other group was diagnosed with patellofemoral pain syndrome and had an increased Q angle. All were tested for isometric knee extension at 90,° 30°, and 15° of knee flexion. Electromyography (EMG) was utilized to test muscle activity of the long fibers and the oblique fibers of the vastus medialis. All other quadriceps muscles were noted between groups or between the three angles mentioned earlier. Therefore, the authors suggested that all the vasti measured were consistently active throughout the entire studied range of motion. Boucher et al. (1992) came to the conclusion that the neural drive was not affected with the patellofemoral patients. However, when the five patients that had the largest Q angles were compared, they had a significantly smaller vastus medialis oblique: vastus lateralis ratio. The researchers also revealed that the patients with patellofemoral syndrome had a less active vastus medialis relative to the vastus lateralis as showed by the EMG's. In reference to biomechanical problems, Boucher et al. (1992) said a knee or ankle malalignment could put the vastus medialis in such a mechanical position that its contribution would be minimized. If the mechanical alignment is allowed to deteriorate further, it could result in increased symptoms. Thus, it was concluded that rehabilitation strategies should include a mechanical management and a functional or neuromuscular management (Boucher et al., 1992).

Livingston (1998) wrote a paper to present a review of the current literature on the quadriceps (Q) angle. Livingston (1998) defined the Q angle by drawing an imaginary line from the anterior superior iliac spine to the center of the patella and from the center of the patella to the middle of the anterior tibial tuberosity (Figure 4). These landmarks are easily palpable and have been the landmarks used in all measurement procedures. However, the methods of measuring the Q angle have not been standardized (Livingston, 1998). A Q angle greater than 15-20° is thought to contribute to knee extensor dysfunction and patellofemoral pain. An increased Q angle is defined as an anatomic risk factor ranging from 0.2° to 1.3°, when the measurements were taken from a supine to a standing position.

In regards to the differences between the male and female Q angle, overwhelming evidence existed that indicated young adult women have a greater mean Q angle than males. The difference between men and women ranged from 2.7°-5.8° in the supine position and 3.4°-4.9° in the standing position (Livingston, 1998). Livingston (1998)