The Effect of Q Angle on Vertical Jump in Female Athletes

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Table of Contents

List of Figures

Abstract

The purpose of the investigation was to determine the relationship between Q angle and vertical jump in female collegiate athletes. The measurement tools used were a goniometer and a Vertec vertical jump stand. This study involved a correlational test. The Q angle measurements of each participant were taken and compared to an average vertical jump height. The analysis of the results from 15 participants revealed no correlation between Q angle and vertical jump. Future research should analyze a larger population of female athletes and should not be limited to age. Future research should also examine different methods of measuring strength other than vertical jump when looking for a correlation with Q angle.

CHAPTER I
OVERVIEW

Female athletes, in general, have more knee injuries than men (Livingston, Mandigo, Benghuzzi, & Bajpai, 1997). Significant injuries to the knee can cause a lifetime of knee complications and can be career ending. Various biomechanical differences between males and females have been hypothesized to be the cause of these findings. One of these differences is that women naturally have wider hips than men. Wider hips provide a larger area for a fetus to develop during pregnancy and cause an increase in the angle of the knee where the femur and tibia come together. This is called the Quadriceps Angle (Q angle.) A normal Q angle in women is 17 degrees (Messier & Pittala, 1988). There is a correlation between a larger Q angle and an increase in knee overuse injuries (Arendt & Draper, 1995). The increase in the Q angle creates more stress on the ligaments and bones of the knee involved. The four ligaments in the knee, (the anterior cruciate ligament, medial collateral ligament, lateral collateral ligament, and the posterior cruciate ligament) are all stressed with an increase in Q angle. Also stressed are the bones of the knee, (the tibia, femur and patella) which are supported by the ligaments.

The Q angle can show how the patella works with the femur and tibia when the knee flexes. When the knee flexes, the patella is most likely to shift laterally or to the outside of the knee joint. If any type of disadvantage occurs mechanically, such as the patella shifts and does not stay in the patellar groove, then performance of the knee decreases.

This research is being done so that strength and conditioning coaches, athletic trainers, and other sports medicine professionals can prevent knee injuries and increase performance. Strength and conditioning coaches as well as athletic trainers can target specific muscle groups to increase or decrease a Q angle. This research is designed to show how affecting the Q angle can increase or decrease performance. Part of an athletic trainer’s job is to prevent injuries. If manipulating the Q angle can decrease injuries, then this research can be very valuable.

Statement of Problem

Previous research shows that an increase in Q angle resulted in a higher risk of knee injury (Livingston, et al., 1997), but very little research has examined the relationship of Q angle and performance, vertical jump. With the proper knowledge of the relationship of the knee’s position compared to the hip, knee injuries can be prevented.

The purpose of this investigation was to determine the relationship between Q angle and vertical jump in female collegiate athletes.

Hypothesis

It was hypothesized that there is no correlation between Q angle and vertical jump in female collegiate athletes.

Operational Definitions

In this study there are two variables, Q angle and vertical jump height. Q angle is defined as the angle formed by a line drawn from the anterior superior iliac spine through the center of the patella and a line drawn from the center of the patella to the center of the tibial tubercle. Vertical jump height can be defined as the act of raising one's center of gravity higher in the vertical plane solely with the use of one's own muscles. It is a measure of how high an individual can elevate (jump) off the ground from a standstill.

CHAPTER II
REVIEW OF LITERATURE

The quadriceps angle, also known as the Q angle, has been linked to anterior cruciate ligament injuries, general knee pain, and patellofemoral pain syndrome in females (Livingston, et al., 1997). Research has focused on using the Q angle as a way to predict knee injuries or a way to explain a knee injury, but there is not a significant amount of studies that have looked at how manipulating the Q angle can increase athletic performance.

Importance and Relevance of the Q Angle

The Q angle of the human body is formed by the femur and the tibia and represents the relationship between the hip and ankle joints. The axis of the angle is formed in the middle of the patella in the knee joint (Prentice, 2006). The Q angle is measured by using a goniometer, placing the axis at the center of the patella, one arm in line with the anterior superior iliac spine and the other in line with the center of the anterior tibial tuberosity (Schulthies & Draper, 1999). Standards for a measurement protocol have not been specified; therefore, drawing conclusions from other Q angle studies is difficult. Some studies have shown that a shift of 0.3º to 1.2º when moving from a standing to supine position (Woodland & Francis, 1992). A normal Q angle is 14º for males and 17º for females. It has been stated in other studies that an excess of 15º-20º can contribute to pain and knee extensor dysfunction, and is often referenced as an anatomic risk factor for patellofemoral joint injuries; however little statistical data supports this claim (Messier & Pittala, 1988).

Previous research studies have found that women have a significantly greater Q angle than men with angles ranging in mean from 2.7º to 5.8º in the supine position and 3.4º to 4.9º in the standing position (Guerra, Arnold, & Gajdosik, 1994). Hvid and Andersen (1982) did report an

8.0º difference in median Q angle between men (12º) and women (20º) suffering from patellofemoral pathologies. No studies examined by Livingston, et al., (1997) showed a mean Q angle greater for males when compared to females. While differences in mean have been documented, the reason for these differences is not as clear. The most obvious would be the structure of females hips compared to males as females hips are designed to bear a child and give birth; therefore, being wider resulting in a greater Q angle (Arendt & Draper, 1995).

Other theories for women having greater Q angles include the theory by Horton and Hall (1989) that states that a shorter femur would translate into a smaller Q angle. Another theory proposes that quadriceps training through physical activity and sports can alter the Q angle (Hahn & Foldspang 1997). Further research is needed, however to make on conclusion about either theory. Hahn and Foldspang also looked at Q angle in relationship to specific sport or activity and found that the Q angle was positively associated with years of jogging and negatively with years of soccer, swimming, and sports participation at all. It was concluded, however, that the use of Q angle measurements is questionable and that there was not enough of a significance to draw a strong conclusion.

In other research conducted on high school cross country running athletes, conclusions by Rauh, Koepsell, Rivara, Rice, and Margherita (2007) were made that runners with greater Q-angle asymmetry were more likely to injure their shin. Knowing which runners are at high risk may help to introduce measures to reduce later risk of injury. They also found that runners with a greater Q angle missed more significant time when compared to injured athletes with smaller Q angles.

Challenges with Q Angle

Some challenges when dealing with the Q angle include, not having a standard protocol for measurement. This also includes studies that publish one Q angle value versus a mean average of Q angle measurement of both leg Q angle measurements. Studies that only have one recorded Q angle are assuming symmetry in both legs of the individual being tested. This assumption is questionable with the studies and findings available. A study conducted by Livingston, et al., (1997), found that in subjects with knee pain, Q angles were not identical. The difference was 0.9º in men and 1.2º in women. When looking at the data further, half of the subjects had a bilateral difference of 4º; and in 10 of the 55 subjects, the difference ranged from 8º to 10.3º.

Another study completed by Shambaugh, Klein, and Herbert (1998) found similar findings in injured versus non-injured male basketball players as Q angles varied from 1.3º to 2.7º. It cannot be concluded from the insufficient evidence available, that Q angles are bilaterally symmetric. What should be taken into consideration, however, is that significant variation between an individual's Q angles may exist naturally.

A big challenge when looking at Q angle before and after injury is having the measurements actually being done on individuals that have been injured. It is very time consuming to measure each athlete pre-participation. A study by Cowan, Jones, Frykman, Polly, Rosenstein and Rosenstein (1996) looked at the effects of anatomic variation on the risk of overuse injuries of young men before completing a 12- week Army infantry training program. He concluded that those with a Q angle of more than 15º had a significantly higher risk of an overuse injury, and he specified stress fracture as an overuse injury that was evident in his study. Other overuse injuries that were found included pain and non-acute muscle strain.

Current Interventions

Very little research has been completed to show that manipulating Q angle translates into manipulating performance, however, there are some interventions that have been tested to manipulate Q angle itself. Kuhn, Yochum, Cherry and Rodgers, (2002) used the intervention of a full-length, flexible orthotic that was inserted into the shoe of the test subject. Measurements were taken before and after the use of the orthotic. The person measuring the subject's Q angles was not aware of whether the subject had the orthotic in place or not. Kuhn, Yochum, Cherry and Rodgers were able to conclude that of the 40 test subjects, 39 of them saw a decrease in Q angle. He also concluded that if other research shows that decreasing Q angle decreases the risk of injury, which has been confirmed, than the long term benefits from use of a flexible orthotic exist.

There is also an assumption that by targeting specific muscle groups, the Q angle of an individual can be manipulated (Livingston, et al., 1997). Although it is not evident that it results in greater athletic performance, decreasing the Q angle has shown to decrease the risk of knee injuries (Rauh, et al., 2007). Targeting a specific muscle group can be completed with the help of a certified strength and conditioning coach, a certified athletic trainer, a physical therapist, or any other sports medicine professional. It is also important to note that changing an individual's Q angle takes a lot of time and dedication, and for some people it is not because personal limitations such as genetics or physical abnormalities that prevent the Q angle from decreasing past a certain parameter.

Summary

Sports medicine professionals can use Q angle to target those athletes at risk and work with them to decrease their Q angle or make them symmetrical. Although decreasing Q angle has not been shown to increase performance, it is just as important that Q angle be used to make sure the athlete is able to participate compared to sitting on the sideline with an ailing injury. It is the goal of every sports medicine professional to prevent injuries and using the early signs of Q angles can be a vital tool to use in any setting.

CHAPTER III
METHODS

Design

This was a correlational study to determine if there is a relationship between Q angle and athlete's performance. Athletic performance was measured by testing the athlete's vertical jump height. Q angle and vertical jump measurements were completed three times and an average was determined as the measurement value of each test.

Participants

Participants consisted of 15 healthy female varsity collegiate athletes, nine were 19 years old and 6 were between the ages of 20 and 21. Participants were determined healthy if they had no history of a knee injury in the past 12 months. Participants were chosen by random selection using a draw from the hat technique from a list of a single university's fall athletic rosters.

Instrumentation

Q-angles were measured using a goniometer, an instrument used to measure angles. The axis was placed on the center of the patella, fixed arm in line with anterior superior iliac spine and movable arm in line with tibial tuberacle. This is the standard method of measuring Q-angle for all health care professionals when referring to anatomical locations. Measurements were recorded to the nearest degree. There is some disagreement when it comes to reliability and validity of the Q angle measurement. There is no standard method of measurement in regards to the position of the participant being measured. For this study, each athlete's Q angles will be measured in a prone position with the knee in full extension. A Vertec (Sports Import, Inc, Columbus, OH) vertical jump stand was used to measure vertical jump in inches, and a mean vertical jump height was recorded.

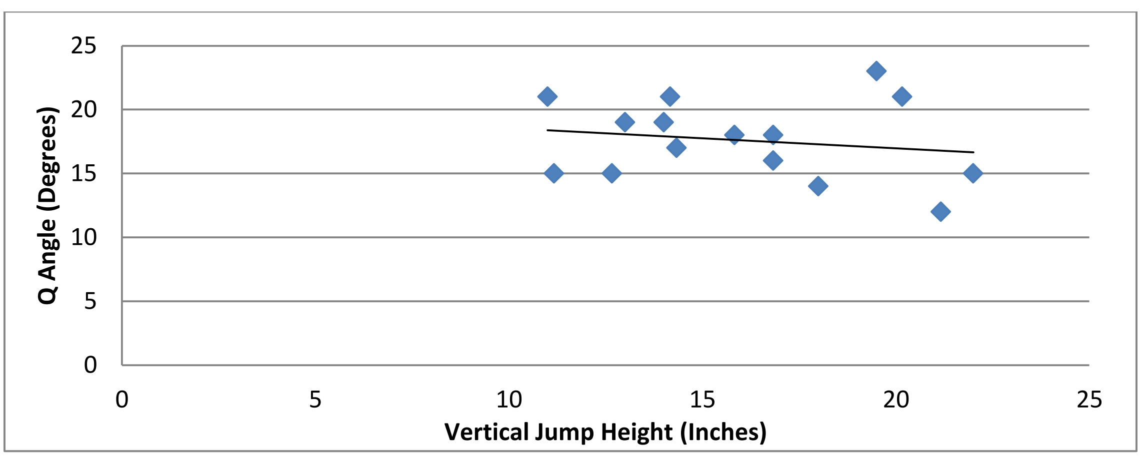
Procedure

The participant was asked to stand with either the left or right arm directly under the Vertec vertical jump-testing device. The researcher then adjusted the height of the bottom vane to the tip of the fingers of the subjects extended arm. Before jumping, the subject was placed in a position so that either the left or right foot was no more than 12 inches from the Vertec device (marked by tape). The foot closest to the Vertec device remained stationary prior to the jump. The applicant then jumped as high as possible, reaching upward at the same time, tapping the Vertec vanes with a hand, causing the vanes to move. This was repeated 3 times and an average was recorded to the nearest half inch. It was assumed that each subject was giving maximum effort.

CHAPTER IV
RESULTS

The analysis of the results from 15 participants revealed no correlation between Q angle and vertical jump. Researchers asked each participant to perform three jumps of maximum effort. A correlation analysis was conducted on Trial 1 vertical jump and Q angle and revealed no significant correlation ($r=.20$ $p\leq.47$). A correlation analysis was conducted on Trial 2 vertical jump and Q angle and revealed no significant correlation ($r=.15$ $p\leq.60$). A correlation analysis was conducted on Trial 3 vertical jump and Q angle and revealed no significant correlation ($r=-.18$ $p\leq.51$). A mean was calculated for each trial in inches (Trial 1 15.83, Trial 2 16.03, Trial 3 16.27). A mean of all trials was calculated resulting in inches 16.04. To obtain an overall score for all participants, a mean for Q-angle was calculated resulting in 17.60 degrees. There was no overall correlation between Q-angle and vertical jump, ($r= -.18$ $p\leq.52$). Figure 1 shows the relationship between mean vertical jump and Q angle for each participant in this study. The line on the graph is a line of best fit, calculated using all data points.

Figure 1. Correlation of Mean Q Angle and Mean Vertical Jump in Female Division III Athletes



CHAPTER V

DISCUSSION

The purpose of this research was to determine if there was a relationship between Q angle and performance, which was tested using vertical jump height as a measurement. The null hypothesis could not be rejected.

Implications of Results

The Q angle shows the relationship the knee has with the acetabulofemoral or hip joint to the talofibular joint in the ankle. This research looked at how the location of the knee could be related to the maximum vertical jump. Each jump trial was compared to the mean Q angle. Additionally the overall mean vertical jump height was compared to the mean Q angle. We found that overall Q-angle did not have a relationship with vertical jump therefore the hypothesis was supported. There was no statistical correlation between mean vertical jump for Trail 1, Trail 2, or Trail 3 and mean Q angle. There was also no statistical correlation between overall vertical jump and overall Q angle. These findings indicate that there is no relationship between Q angle and vertical jump.

Theoretical Consequences

When looking at Q-angle and vertical jump, the results may suggest that biomechanics are not the main factor in maximum vertical jump, but rather researchers need to look at strength and power. Studies have shown a relationship between knee extension strength and vertical jump; as knee extension strength increased so did vertical jump (Guerra, et al., 1994).

The results were unable to support theories about the relationship between Q angle and performance. Theories suggest that performance, in this study vertical jump, would be directly related to the participants Q angle. Extreme variations of Q angles need to be studied in order to draw a more definitive conclusion.

Threats to Validity

A threat to internal validity for this study would be how measurements and testing was conducted. When measuring Q angle, there is a lot of room for error. For this research a goniometer was used to measure the participant lying on a treatment table in a supine position. Other research studies have measured the Q angle in a standing position and some have measured the Q angle in a squat position. Another method of measuring Q angle is to use electromagnetic radiation (X-ray) and measure the image using computerized software. This produces a much more accurate measurement.

Another threat to internal validity for this study would be assuming that each athlete was giving maximum effort in the vertical jump test. The protocol for testing was consistent for each participant, but we have to assume that each athlete displayed maximum effort. For this study, stretching before completing the vertical jump test was not required and should have been taken into consideration. Type of stretching has been shown to have an effect on vertical jump height. It has been shown that 20 minutes of ballistic stretching with a warm up before vertical jump testing, improves overall maximum vertical jump when compared to static stretching (Guerra, et al., 1994). Although this study did not use athletes with a past medical history of knee injuries over the past 12 months, it did not take into count if a participant was feeling any muscle soreness prior to the testing. A threat to external validity include the fact that such a small population was used in this study and may not represent all female athletes accurately.

Implications for Future Research

Future research should look at a larger population of female athletes and should not be limited to age. More restrictions should be put on what the athlete does before vertical jump testing. This could include a stretching or warm-up protocol. Future research should also look at different methods of measurement of the Q angle. Using a more accurate method, such as an X-ray or an electronic goniometer, could show significant results. Future research should also look at different methods of measuring strength other than vertical jump when looking for a correlation with Q angle.

Connections to Previous Research

The results of this study showed that the Q angle does not have an effect on performance. An extremely large or small Q angle, does not translate to a decrease or an increase in vertical jump. Although the results were not significant, research has shown that the Q angle can be used to predict knee injuries specifically, anterior cruciate ligament injuries, general knee pain, and patellofemoral pain syndrome (Livingston, et al., 1997). In other research, conducted by Rauh, et al., (2007), conclusions were made that runners with greater Q-angle asymmetry were more likely to injure their shin. This research study also found that runners with a greater Q angle missed more significant time when compared to injured athletes with smaller Q angles.

Conclusion/Summary

Female athletes have been shown to have a greater Q angle and are at more risk for knee injuries than males (Livingston, et al., 1997). The research looked at how a female athletes Q angle is related to performance which was measured using the vertical jump test. Results, however, showed no significant correlation when comparing vertical jump height and Q angle. All measurements were completed manually, and it is assumed that participants gave their maximum effort when completing the vertical jump test.

Clinically, researchers recommend that athletic trainers, physical therapists and strength and conditioning coaches look at the mechanics of the knee joint in female athletics. Although this research study did not show any significance, it is important for professionals to incorporate programs to further increase the stability of the patella and put the knee joint in a position that has the greatest mechanical advantage.

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