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Clinical Biomechanics 20 (2005) 966–972
CLINICAL BIOMECHANICS
www.elsevier.com/locate/clinbiomech

Differences in peak knee valgus angles between individuals with high and low *Q*-angles during a single limb squat

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Received 7 July 2004; accepted 19 May 2005

Abstract

Background. Differences in anatomical alignment between genders have been suggested as causes of the disparity in anterior cruciate ligament injury rates. A larger *Q*-angle may be associated with increased knee valgus during movement resulting in anterior cruciate ligament strain. This study investigated whether healthy college-aged subjects with a large *Q*-angle display greater peak knee valgus during a single limb squat compared to those with a small *Q*-angle. The study also determined whether the high and low *Q*-angle groups displayed differences in other select anatomical variables, and whether these anatomical variables were related to knee valgus.

Methods. Twenty subjects, categorized as having a "high *Q*-angle" ($\geqslant 17°$) or a "low *Q*-angle" ($\leqslant 8°$) were videotaped during the performance of a single leg squat. The peak valgus angles for the right knee were calculated. One-tailed independent measures *t*-tests were used to determine whether individuals with a large *Q*-angle exhibit (1) significantly greater peak knee valgus during a single leg squat compared to those with a small *Q*-angle and, (2) greater pelvic width to femoral length ratios and greater static knee valgus than subjects with a small *Q*-angle. The Pearson product–moment correlation was used to establish the relationships between pelvic width to femoral length ratios and static knee valgus, pelvic width to femoral length ratios and dynamic knee valgus, and static knee valgus and dynamic knee valgus.

Findings. Peak knee valgus during the single leg squat, and static knee valgus were not significant greater in the high *Q*-angle group compared to the low *Q*-angle group ($P = 0.09$; $P = 0.31$). Subjects with a larger *Q*-angle, however, had a significantly greater pelvic width to femoral length ratios ($P = 0.015$) compared to subjects with a small *Q*-angle. Pelvic width to femoral length ratios was related to both static and dynamic knee valgus ($r = 0.47$, $P = 0.02$; $r = 0.48$, $P = 0.02$), but static knee valgus was not related to dynamic knee valgus.

Interpretation. The findings suggest that pelvic width to femoral length ratios, rather than *Q*-angle, may be a better structural predictor of knee valgus during dynamic movement.

Keywords: Anatomical alignment; Frontal plane kinematics; Anterior cruciate ligament injury; Closed-chain squat

1. Introduction

Non-contact anterior cruciate ligament (ACL) injury rates in female athletes are reported to be three to eight times greater than that of male athletes (Arendt et al., 1999; Lindenfield et al., 1994; Moul, 1998). Skeletal alignment differences between sexes, such as a greater

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0268-0033/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.clinbiomech.2005.05.008

hip width to femoral length ratio (Horton and Hall, 1989), and a larger quadriceps angle (*Q*-angle) (Woodland and Francis, 1992; Horton and Hall, 1989) are thought to contribute to excessive amounts of knee valgus (lateral angulation or abduction of the tibia with respect to the femur). The combination of knee valgus (tibial abduction) and external rotation positions contribute to ACL impingement and injury (Fung and Zhang, 2003; Lephart et al., 2002).

A *Q*-angle greater than 15–20° is more prevalent in women (Hvid et al., 1981). This structural variation may be a factor in the disparity in ACL injury rates between male and female athletes (Huston et al., 2000; McLean et al., 1999; Moul, 1998). The *Q*-angle represents the direction of pull of the quadriceps muscles through the patella to its insertion on the tibial tuberosity (Huberti and Hayes, 1984). Measured statically, it is the angle formed by the intersection of lines drawn from the anterior-superior iliac spine (ASIS) to the mid-patella, and from the mid-patella to the tibial tuberosity. Therefore, it is strongly influenced by the position of the patella and that of the tibial tubercle. It has been proposed that structural factors such as large *Q*-angles may be associated with greater genu valgus (Hutchinson and Ireland, 1995; Horton and Hall, 1989). Conventional wisdom has suggested that females have wider pelvises, which contribute to larger *Q*-angles (Zeller et al., 2003; Griffin et al., 2000; Harmon and Ireland, 2000; Huston et al., 2000). A growing body of evidence, however, dismisses the fact that women have wider pelvises than men (Kernozek and Greer, 1993; Woodland and Francis, 1992; Horton and Hall, 1989). Rather, Horton and Hall (1989) suggest that females exhibit a greater hip width to femoral length ratio, which likely contributes to greater knee valgus.

While *Q*-angle has been suggested to be a structural risk factor for ACL injury, it is primarily a measure of patellofemoral alignment. *Q*-angle may be increased simply by having a laterally displaced tibial tubercle. Therefore, a large *Q*-angle can be present without any genu valgus. To date, there have been no studies of the relationship between *Q*-angle and genu valgus.

Therefore, the purpose of this study was threefold. The first aim was directed at examining whether individuals with a large *Q*-angle have an increased angle of knee valgus during a single limb squat compared to subjects with a small *Q*-angle. It was hypothesized that there would be a significantly greater amount of peak knee valgus for a group of subjects with large *Q*-angles compared to those with a small *Q*-angle, based on the theory that larger *Q*-angles would create greater angulation of the lower extremity resulting in increased valgus angles during the squat. A second aim was to determine whether subjects with a large *Q*-angle exhibit greater pelvic width to femoral length (PW/FL) and static knee valgus than those with a small *Q*-angle. It was hypothesized that subjects with a large *Q*-angle would exhibit greater PW/FL and static knee valgus that those subjects with a small *Q*-angle. Lastly, the relationships between PW/FL and static knee valgus, PW/FL and dynamic knee valgus, and static knee valgus and dynamic knee valgus were examined. It was hypothesized that moderate to strong relationships ($r > 0.50$) (Portney and Watkins, 2000) would exist between PW/FL and static knee valgus, PW/FL and dynamic knee valgus, and static knee valgus and dynamic knee valgus during a single leg squat.

2. Methods

2.1. Subjects

Twenty subjects (11 males, 9 females; mean age 22.9 (SD 2.7) years, range 18–29 years; mean mass 71.6 (SD 15.6) kg; mean height 170 (SD 11.7) cm from the general college population were classified into high and low *Q*-angle groups, according to the degree of *Q*-angle that each subject exhibited (Table 1). Subjects having any right knee pathology or surgery within the last five years and/or any prior right limb injury in the last year were excluded from the study. The number of subjects required for the study was determined from a power analysis conducted a priori, based on an expected large effect using a minimally clinical important difference of 5° between subject groups with a projected variability of 3.3° and power greater than 0.80. All subjects gave written consent, approved by an Institutional Review Board, to participate in the study.

The criteria used to place the subjects into high and low *Q*-angle groups were based on data taken from 204 male and female college students whose mean *Q*-angle was 12.5° (SD 4.6°). The mean *Q*-angle values established for our population sample were comparable to mean values reported by Horton and Hall (1989) (13.5° (SD 4.5°)). Accordingly, the "low *Q*-angle" group was defined as being 8° or less, which represents the group mean minus one standard deviation (12.5–4.6°). Subjects exhibiting a *Q*-angle of $\geqslant 17°$ (the mean plus one standard deviation) were placed in the "high

Table 1
Description of subjects reported as means (SD)

Groups ($n = 20$)	High *Q*-angle[a]	Low *Q*-angle[b]
Q-angle (°)	22 (3)	7 (1)
Pelvic width/femoral length (cm)	0.63 (0.08)	0.56 (0.05)
Static knee valgus angle (°)	2.9 (2.7)	2.9 (2.9)
Age (years)	22 (3)	24 (3)
Height (cm)	166.1 (12.0)	173.9 (10.5)
Weight (kg)	68.7 (20.2)	74.5 (9.4)

[a] High *Q*-angle is defined as $\geqslant 17°$ (7 females and 3 males).
[b] Low *Q*-angle is defined as $\leqslant 8°$ (8 males and 2 females).