

THE RELATIONSHIP BETWEEN HIP AND KNEE STRENGTH AND VALGUS KNEE POSITION DURING A SINGLE LEG SQUAT

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INTRODUCTION

The control of knee motion in the frontal plane (varus/valgus) is achieved via three stabilizing mechanisms including tibio-femoral joint contact, as well as passive and active restraint systems. The active restraint system refers to the muscles that activate to control or produce motion (American Academy of Orthopaedic Surgeons, 1991). While muscular control of the knee in the sagittal plane has been well documented, it remains unclear what muscles contribute to varus and valgus control during functional weight bearing activities.

Dynamic control of the knee in the frontal plane, particularly in the valgus direction, has practical relevance with regards to injury prevention. A valgus knee angle not only places strain on the passive medial restraint system of the knee, but in combination with anterior tibial translation, strain on the anterior cruciate ligament is increased significantly (Berns et al., 1992). Consequently, understanding muscle contribution to the frontal plane active restraint system of the knee may have practical applications in strength training for sport and injury prevention.

The purpose of this investigation was to determine the relationship between hip and knee strength and valgus knee position during a single leg squat. Additionally,

gender differences in knee joint kinematics and strength were determined.

METHODS

Thirty healthy adults (15 males, 15 females) participated in two separate testing sessions. During the first testing session, each subject was instructed to stand on their preferred leg, squat to approximately 1.05 rad of knee flexion, and return to the standing position. Frontal plane (varus/valgus) knee movement was evaluated kinematically using a Motion Analysis three dimensional system, at a sampling rate of 60 Hz. The SLS was repeated five times with two minutes of rest between each squat. During the second session, isokinetic concentric and eccentric hip and knee strength was tested using a Biodex isokinetic dynamometer at 1.05 rad·s⁻¹. Motions tested included hip abduction (ABD), adduction (ADD), flexion (FLEX) extension (EXT), internal rotation (IR), external rotation (ER), knee flexion (KF), and knee extension (KE). Three maximal-effort reciprocal repetitions were performed for each movement with two minutes of seated rest between sets.

RESULTS

Absolute and body mass normalized peak torque values for concentric and eccentric ABD, ADD, FLEX, EXT, IR, ER, KF, and KE strength measurements were used for analysis. An independent t-test

demonstrated that female subjects produced significantly less absolute peak torque than males for all strength measurements except eccentric IR ($p < 0.05$). When normalized to body mass, gender differences were noted for concentric ADD, FLEX, KF, and KE, and eccentric EXT ($p < 0.05$).

In the standing position, male and female subjects presented with a slightly varus knee position (males = 0.034 ± 0.071 rad, females = 0.011 ± 0.035 rad). During the SLS, the peak knee flexion angle for males and females was 1.09 ± 0.167 rad and 1.15 ± 0.136 rad respectively (mean \pm SD). When performing the SLS, females demonstrated a peak knee valgus angle of 0.064 ± 0.080 rad, and males showed a peak knee valgus angle of 0.048 ± 0.092 rad (mean \pm SD). During the SLS, females moved in the valgus direction 0.064 ± 0.080 rad (mean \pm SD), while males moved toward the varus direction 0.012 ± 0.168 (mean \pm SD). There were no significant gender differences noted for all measurements of frontal plane knee kinematics ($p > 0.05$).

Linear regression analysis revealed that concentric ABD ($r^2 = 0.13$, SEE = 8.11), KF ($r^2 = 0.18$, SEE = 7.88), and KE ($r^2 = 0.14$, SEE = 8.10) peak torque were significant predictors ($p < 0.05$) of frontal plane motion of the knee during a SLS. A Pearson product moment correlation demonstrated weak to moderate, but significant negative relationships between the concentric ABD ($r = -0.37$, $p < 0.05$), KF ($r = -0.43$, $p < 0.01$) and KE ($r = -0.37$, $p < 0.05$) peak torque, and frontal plane knee motion. These data suggest that individuals with greater strength of these muscle groups, tend to demonstrate a lower amount of knee movement in the valgus direction. There were no significant relationships between peak torque and standing knee valgus or peak knee valgus.

When considering all of the strength variables collectively in a factor analysis, a regression analysis showed that only the knee factor ($r^2 = 0.22$, SEE = 7.85) was a significant predictor of frontal plane knee motion. When interpreting the knee factor, strength of all of the hip and knee muscle groups are taken together. High loadings of concentric and eccentric KF, KE, IR and concentric ABD suggest that strength of these muscle groups may contribute more than others when predicting motion of the knee in the frontal plane.

SUMMARY

These data suggest that increased frontal plane knee movement toward valgus direction may occur when ABD, KF, and KE peak torque values are relatively low. These findings are in agreement with previous work demonstrating a significant contribution of the quadriceps, hamstrings, hip abductors and hip adductors to the control of varus and valgus motion at the knee (Lloyd & Buchanan, 2001).

When normalized for body mass, females exhibited lower strength values in KF and KE strength when compared to males, possibly implying a gender predisposition to increased knee motion in the valgus direction during functional weight bearing activities.

REFERENCES

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