UTILITY OF THE FRONTAL PLANE PROJECTION ANGLE OF THE KNEE DURING SINGLE LEG SQUATS

John D. Willson[1] and Irene Davis[1,2]
[1] Department of Physical Therapy, University of Delaware, Newark, DE, USA
[2] Drayer Physical Therapy Institute, Hummelstown, PA, USA
Email: willson@udel.edu Web: www.udel.edu/PT/davis/index.htm

INTRODUCTION

Abnormal lower extremity mechanics during athletic activities are believed to contribute to the etiology of numerous knee joint injuries [1,2]. The single leg squat test is commonly used by practicing clinicians to identify individuals who display such abnormal mechanics. Presently, due to the restraints of typical clinical settings, analysis of this test is done qualitatively. However, quantification of a patient's performance on this test would facilitate accurate documentation of these mechanics as well as changes due to interventions. Two-dimensional images recorded by a digital camera during this test will reveal the frontal plane projection angle (FPPA) of the knee during this test. However, it is unclear to what extent the frontal plane projection angle determined using such methods is related to actual three-dimensional (3D) kinematics. Specifically, it would be beneficial to know to what degree tibiofemoral (TF) valgus, a widely accepted risk factor for injuries such as ACL rupture and patellofemoral pain, is represented by such images. Additionally, the extent to which performance on the single leg squat test is associated with lower extremity alignment during faster, more demanding tasks has not been determined.

The purpose of this study was to examine the correlation of the FPPA of the knee during single leg squats with hip and knee frontal and transverse plane kinematics. Second, we analyzed to what extent the FPPA of the knee during single leg squats reflects knee and hip kinematics during a single leg landing. We hypothesized that the FPPA during single leg squats would be significantly correlated with TF valgus during single leg squats and landings.

METHODS

As part of an ongoing study, 10 healthy subjects performed five single leg squats and five single leg landings. All trials were collected for the dominant leg of each subject. Retroreflective markers placed on the lower extremity were tracked by a six camera Vicon motion analysis system collecting at 120 Hz. V3D software was used to determine lower extremity kinematics. Markers placed on the leg of each subject bisecting the frontal plane of the proximal thigh, TF joint, and malleoli at the ankle were used to determine the FPPA of the knee in each digital image (CorelDraw). Subjects performed each single leg squat to a cadence and a self-selected depth. Single leg landings were performed from a height of 23 cm. During each squat trial, a digital image was recorded by a camera placed 2m anterior to the subject, perpendicular to the frontal plane, and at the height of the knee joint in single leg stance. Each image was recorded as the subject passed 45º knee flexion as determined by an electrogoniometer on the lateral aspect of the leg. To synchronize the digital camera with the motion analysis, a signal was delivered to the motion analysis workstation as the image was recorded. Pearson correlation coefficients were calculated between the FPPA and selected 3D kinematics during single leg stance and landing conditions.

RESULTS AND DISCUSSION

The FPPA was significantly associated with transverse plane kinematics at the knee (Table 1). 3D TF valgus was weakly associated with the FPPA during single leg squats (Figure 1). During single leg landings, the FPPA was more highly correlated with peak TF internal rotation ($r = .66$, $p = 0.04$) than peak TF abduction ($r = .54$, $p = 0.11$). After ten subjects, it appears that interpretation of the FPPA should not neglect the influence of transverse plane motion on this measure. However, we are collecting additional subjects to sufficiently power the study.

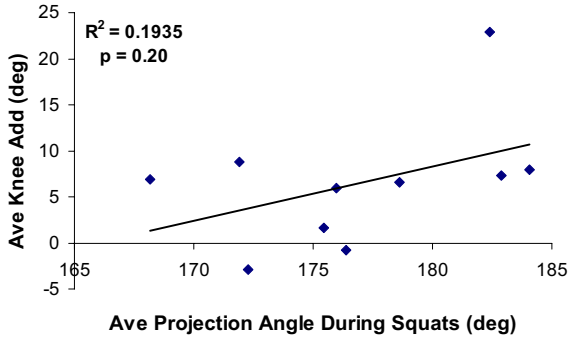

Figure 1: Knee abduction angle determined using rigid body analysis versus the FPPA during single leg squats.

CONCLUSIONS

Based on these preliminary data, the FPPA of the knee during single leg squats appears to indicate the degree of TF valgus to a limited extent. A greater correlation between knee transverse plane kinematics and FPPA has been identified. The FPPA during a single leg squat also appears to lend insight into the degree of knee internal rotation during a single leg landing.

REFERENCES

1. Griffin, L. *J Am Acad Orthop Surg*. **8**:141-150, 2000.
2. McClay Davis, I. *Clin Biomech*. **16**:937-959, 2001.

Table 1. Correlation between the average FPPA and hip and knee frontal and transverse plane kinematics during single leg squats.

	Knee abd/add	Knee IR/ER	Hip abd/add	Hip IR/ER	Femur abd/add (global)	Femur IR/ER (global)
Pearson r *(p)*	0.44 *(0.20)*	0.84 *(0.002)*	-0.29 *(0.42)*	-0.20 *(0.59)*	-0.73 *(0.02)*	-0.27 *(0.46)*