

THE INFLUENCE OF RELATIVE HIP AND KNEE EXTENSOR STRENGTH ON LOWER EXTREMITY BIOMECHANICS DURING A DROP LAND TASK

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INTRODUCTION

Tears of the anterior cruciate ligament (ACL) are 4-6 times more likely to occur in females, as compared to males [2]. While the cause for this discrepancy in ACL injury rates is unknown, specific biomechanical profiles have been identified that may place females at greater risk of injury. For example, females demonstrate increased valgus moments at the knee, which have been directly linked to an increased risk of ACL injury [2]. Additionally, females tend to demonstrate decreased hip and knee flexion, increased knee extensor moments, and decreased energy absorption at the hip during landing [1,2].

One possible explanation for these gender specific differences in landing strategies may be related to weakness of the hip muscles, which provide dynamic stability during landing. In particular, weakness of the hip extensors relative to the knee extensors may cause an over-reliance on the knee musculature and associated passive structures (i.e. ligaments) to absorb impact forces during landing [3,4,5]. The purpose of this study was to investigate the influence of hip extensor muscle strength relative to knee extensor muscle strength on lower extremity biomechanics during landing.

METHODS

Eight healthy females, free from lower extremity pathology or previous injury, participated in 2 data collection sessions: 1) kinematic and kinetic assessment during a drop landing task from a 14 in box, and 2) isometric strength testing of hip and knee extension using a Cybex Isokinetic dynamometer. All data was collected from the

dominant lower extremity, defined as the leg with which the subject would prefer to kick a ball.

Lower extremity kinematics and ground reaction forces were collected using an 8-camera Vicon Motion Analysis System (Vicon 612, Oxford, UK; 250 HZ) and 2 floor-embedded force plates (AMTI, Watertown, MA; 1500 Hz). Peak knee valgus moments, peak hip and knee flexion angles, and hip energy absorption were calculated during the deceleration phase of the drop land, as defined by the time from initial foot contact on the force plate to peak knee flexion angle.

For the strength testing, subjects performed 3 maximum isometric contractions of 5 seconds duration for both hip and knee extension. The average isometric torque produced during the best repetition was used to calculate the hip/knee extensor strength ratio (HKR). A strength ratio greater than 1 indicated that hip extensor muscle strength was greater in magnitude than knee extensor muscle strength, while a strength ratio less than 1 indicated that isometric knee extensor muscle strength was greater in magnitude than hip extensor muscle strength. The 6 subjects were then divided into 2 groups based on the results of their strength results. Three of the subjects had a HKR greater than 1, and 3 subjects had a HKR less than 1.

Comparisons of kinematic and kinetic variables between the 2 groups were made using independent samples t-tests. In addition, linear regression analysis was performed to determine the relationship between the HKR and the peak valgus moment.

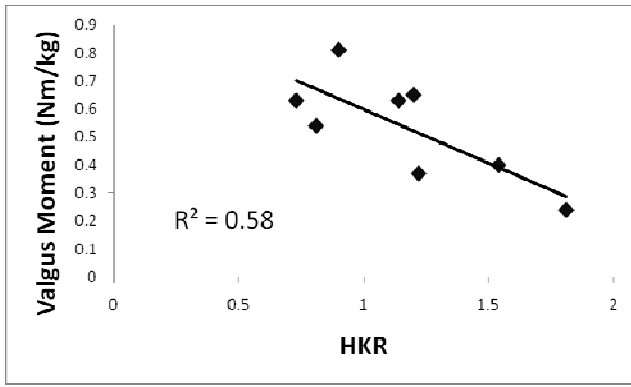


Figure 1: Peak knee valgus moments plotted against the HKR for all 8 subjects included in the study. Linear regression produced an $R^2 = 0.58$

RESULTS

Table 1 provides a summary of the average data averaged for the 2 groups of subjects. The 5 subjects in the high HKR group (i.e. $HKR > 1$), had an average ratio of 1.38 ± 0.3 , while the 3 subjects in the low HKR group (i.e. $HKR < 1$), had an average ratio of 0.81 ± 0.1 . When compared to the low HKR group, subjects in the high HKR group had lower peak knee valgus moments, greater peak hip and knee flexion angles and greater energy absorption at the hip. Linear regression of the HKR on the peak knee valgus moment for all the subjects resulted in a R^2 value of 0.58 ($p < 0.05$), indicating that 58% of the variance in peak knee valgus moment could be explained by the HKR.

DISCUSSION

Although our study included only a small number of subjects, distinct differences in landing strategies were noted between the two groups. In general,

individuals with a lower HKR tended to land using a biomechanical pattern thought to increase knee loading (i.e. diminished sagittal plane motion and increased frontal plane moments). Conversely, subjects with high HKR's demonstrated improved energy absorbed at the hip and a biomechanical strategy thought to be less "at risk" for knee injury. The results of the linear regression analysis support the premise that strength of the sagittal plane musculature is associated with frontal plane knee moments.

CONCLUSIONS

These results indicate that the relative strength of the hip extensors, compared to the knee extensors, may influence hip and knee biomechanics during landing. Our results suggest that interventions aimed at strengthening the hip extensors may improve the lower extremity biomechanics associated with knee injury in female athletes, however additional research would be needed to test this hypothesis.

REFERENCES

1. Decker MJ, et al. *Clin Biomech* **18**, 662-669, 2003.
2. Hewett TE, et al. *Am J Sports Med* **33**, 492-501, 2005.
3. Schmitz RJ, et al. *Clin Biomech* **22**, 681-688, 2007
4. Pollard CP, et al. *Clin J Sport Med* **17**, 38-42, 2007.
5. Zazulak BT, et al. *JOSPT* **35**, 292-299, 2005

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Table 1: Summary of the HKR and biomechanical variables calculated over the deceleration phase of the drop land for the subjects with the high and low HKR.

Group	HKR	Knee Valgus Moment (Nm/kg)	Peak Knee Flexion Angle (Degrees)	Peak Hip Flexion Angle (Degrees)	Hip Energy Absorption (Watts/kg)
High HKR (n=3)	1.38 ± 0.3	0.45 ± 0.09	87.6 ± 8.6	73.8 ± 5.5	160.18 ± 14.5
Low HKR (n=3)	0.81 ± 0.1	0.66 ± 0.14	81.9 ± 11.5	68.0 ± 9.5	110.6 ± 45.4