HIP ROTATION RANGE OF MOTION AND ITS IMPACT ON LOWER LIMB ALIGNMENT ON LANDING

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The purpose of the present study was to compare lower limb alignment at initial ground contact between groups with normal and abnormal hip rotation range of motion. Male (n=8) and female (n=8) subjects performed an maximal drop jump diagonal side cut task ten to the left and ten to the right. Lower limb alignment was assessed through knee angle, hip angle, ankle angle, thigh rotation and shank rotation at initial foot contact. One significant difference was reported between groups for the knee angle variable on the non dominant side. This indicates that the only the knee angle variable is affected by unbalanced hip rotation range of motion and on the non-dominant side.

KEY WORDS: Anterior Cruciate Ligament, joint angles, limb dominance, segment rotations

INTRODUCTION: Anterior cruciate ligament (ACL) injuries are well recognised as one of the most common and serious sports injuries with upwards of 250,000 ACL injuries in the United States each year (Boden *et al.* 2000). Seventy two percent of non-contact ACL injuries occur at or shortly after foot strike (Myklebust *et al.* 1997, Olsen *et al.* 2004). Lower limb alignment at the moment of foot strike has been shown to effect valgus loading at the knee (McLean *et al.*, 2004a; Zeller *et al.*, 2003) with greater valgus loads increasing ACL injury risk. Numerous factors can alter lower limb alignment at landing such as hip joint neuromuscular control, strength and range of motion (ROM). Neuromuscular control at the hip has been suggested to be functional as a means of countering ACL injury inducing valgus loads (Besier *et al.* 2003, Lloyd and Buchanan 2001, Zhang and Wang 2001). Decreased ROM at the hip has also been linked to injury risk for conditions such as lower back pain (Verrall *et al.* 2007, Ireland and Wall 1990). Hip rotation ROM has also been shown to differentiate ACL injured subjects from the general population (Gomes et al 2008); it is unclear if this would still be the case prospectively. Lower limb alignment at landing and hip function have been previously investigated in terms of their affect on valgus loading and ACL injury risk however there is no indication of any interaction between the two. This study aimed to investigate differences in initial contact lower limb alignment dependent variables (knee angle, hip angle, ankle angle, thigh rotation, shank rotation) between two subject groups divided according to hip rotation ROM balance (independent variable) normal with external rotation <10° different from internal rotation (balanced) and abnormal with >10° difference (unbalanced). It was hypothesised that the group with abnormal hip rotation would display different landing alignment to that of the group with normal hip rotation ROM.

METHOD: Subjects included eight males (age 21 ± 3 yrs; height 1.79 ± 0.06 m; mass 76 ± 6 kg) and eight females (age 21 ± 2 yrs; height 1.68 ± 0.07 m; mass 64 ± 7 kg). Passive hip rotation ROM assessment took place prone on a plinth style bed (Harris-Hayes *et al.* 2007) using manual pelvic stabilisation and a bio-med gravity based inclinometer for measurement of shank orientation (Cibulka *et al.* 1998). Following ROM and maximum drop jump height assessment subjects completed 20 trials of a dynamic task. This involved dropping from a 0.30 m bench, and performing an immediate drop jump up to reach and touch a target which was suspended at their maximum drop jump height. The suspended target triggered a directional cueing system which indicated which direction the subject had to run diagonally to on landing (10 left 10 right), set up is shown in Figure 1.

Data Collection: A six-camera high-speed motion analysis system (Eagle; Motion Analysis Corp., Santa Rosa, CA) (500Hz) was synchronised with an AMTI dual force platform system (1000 Hz). 43 retro-reflective markers were secured on the asis, psis, sacrum, iliac crest, greater trochanter, medial and lateral epicondoyle and malleolus, upper and lower calcaneous, 2nd and 5th metatarsal of both legs four marker clusters were also placed on the thigh and shank. Each subject stood for a static trial prior to full data collection.

Data Analysis: Hip rotation groupings were defined as mentioned according to hip rotation ROM. The abnormal grouping was unidirectional demonstrating an increased level of external rotation. These groups had significantly different internal external rotation ratio's with

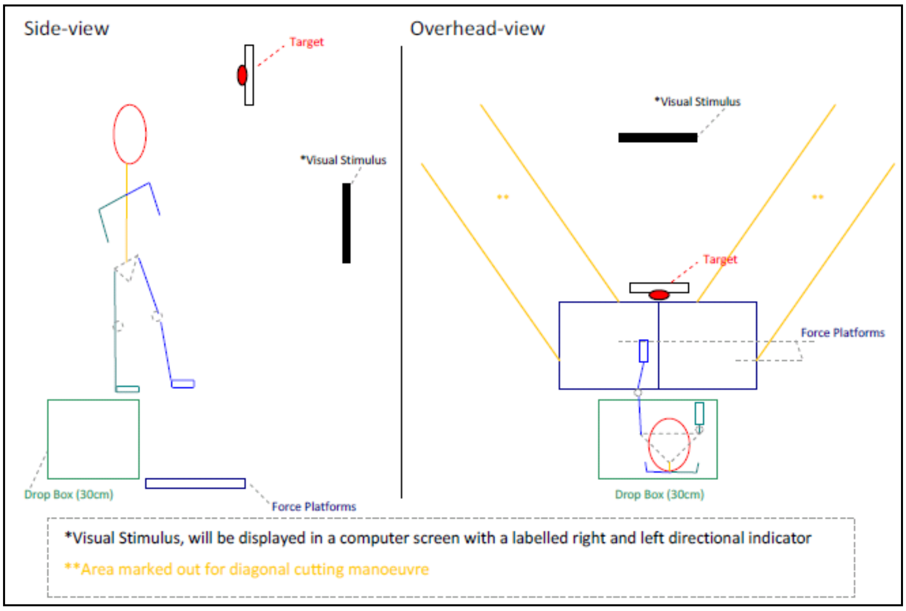

Figure 1. Dynamic Task Set Up

a mean difference of 29°*. Knee hip and ankle angles were presented as anatomical angles thigh and shank rotations were presented as the difference between standing postition (static trial) and the position at ground contact. The differences between the hip rotation groups were assessed by a one way anova and Cohen's d was used as a measure of effect size. Pearson's correlation was also used to assess correlations between ROM internal external rations and the dependant variables.

RESULTS: Average values for all lower limb alignment variables recorded at ground contact are presented in Table 1 for both groups. One significant difference was found between the groups for the knee angle variable on the dominant leg. The group with abnormal hip rotation ROM demonstrated significatly more knee extension on landing in their non-dominant leg that the normal hip rotation ROM group. There was a very strong effect size also shown for this variable.

Table 1 Lower limb alignment variables at initial contact for both groups

	Normal Hip ROM		>Ext Hip ROM		*p*-value		Cohen's *d*	
(°)	Dominant	Non-Dominant	Dominant	Non-Dominant	Dominant	Non-Dominant	Dominant	Non-Dominant
Knee Angle	159	**156***	162	**168***	0.258 [a]	**0.003*** [f]	0.59	**1.78**
Hip Angle	131	122	126	122	0.181 [b]	0.871 [g]	0.73	0.08
Ankle Angle	133	133	125	125	0.309 [c]	0.305 [h]	0.55	0.55
Thigh Rotation	32	26	34	33	0.8 [d]	0.317 [i]	0.13	0.52
Shank Rotation	19	14	10	23	0.26 [e]	0.144 [j]	0.59	0.78

Power Analysis [a]= 0.196 [b]=0.259 [c]=0.166 [d]=0.057 [e]=0.195 [f]=0.897 [g]=0.053 [h]=0.168 [i]=0.162 [j]=0.302

When a Pearson's correlation was implemented on hip rotation range of motion and each dependent variable one distinct relationship was shown for knee angle on the non dominant leg with a correlation coefficient of 0.54*, significant at 0.030 (Figure 2).

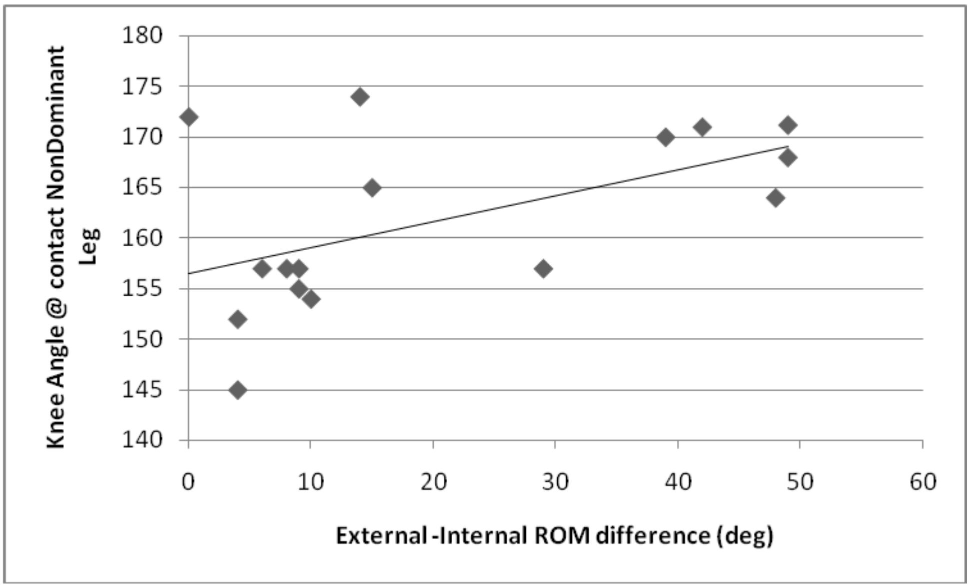

Figure 2. Knee Angle - Hip Rotation ROM Correlation

DISCUSSION: The purpose of this study was to investigate any differences in initial contact lower limb alignment variables (knee angle, hip angle, ankle angle, thigh rotation, shank rotation) between two subject groups divided according to hip rotation ROM. There was one significant difference shown between the two groups (non dominant knee angle) but overall the proposed hypothesis was not supported. There has been no previous research assessing the interaction between initial contact lower limb alignment and levels of hip rotation ROM. This investigation is therefore important in establishing that hip ROM does not have a significant effect on all of the landing alignment variables. The one variable that did show an interaction with hip rotation ROM was knee angle on the non dominant leg. Non-dominant knee angle at contact was significantly different between groups with a strong effect size and 29% of its variability was explained by each subject's hip rotation ROM (Pearson's correlation coefficient 0.54). The knee at ground contact in the abnormal hip rotation ROM group was significantly more extended which has been cited as a potential risk factor for ACL injury (Boden *et al.* 2000). The fact that this is only the case in the non-dominant limb is also interesting as limb dominance has also been assessed as a potential ACL injury risk factor It is thought that more ACL injuries occur on the non-dominant side but this has not yet been proven conclusively (Matava *et al.* 2002). Overall the proposed hypothesis was not supported as only one of five variables differed between groups. As stated in the introduction many factors affect lower limb alignment at landing; it is plausible that factors such as neuromuscular control and strength around the hip joint may demonstrate a stronger effect than the variables utilised in this study on lower limb alignment at landing. Additional measures that were not employed in this study which would have provided further depth to the investigation was valgus angle and joint moments, future analysis of those variables for the given data is planned. Areas that may alter lower limb alignment on landing and may merit future research include neuromuscular control, and strength at the hip. Variables such as muscle strength can be easily targeted in injury prevention interventions for the production of safer lower limb alignments at landing.

CONCLUSION: One variable from five lower limb alignment variables was shown to be significantly different when compared in terms of hip rotation, this variable was knee angle on the dominant leg. This relationship between knee angle and hip rotation is important as the more extended position adopted by those with abnormal hip rotation ROM may place them at an increase risk of ACL injury. Hip rotation ROM is easily targeted by stretching interventions which may act to decrease knee extension at ground contact and decrease injury risk. Future research is necessary to investigate the relationship between other hip joint functional measures such as strength and balance etc. This would assist in the development of other appropriate injury prevention programmes for the alteration of lower limb alignment at landing to decrease injury risk.

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