ISB 2013 BRAZIL
XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS
XV BRAZILIAN CONGRESS OF BIOMECHANICS

THE EFFECT OF DROP LANDING HEIGHT ON BIOMECHANICAL RISK FACTORS AND THE NEUROMUSCULAR PROTECTIVE MECHANISM OF THE ANTERIOR CRUCIATE LIGAMENT INJURY IN FEMALE SOCCER PLAYERS

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SUMMARY
Strengthening the hamstrings through an intervention program would have a positive impact on preventing ACL injury during sport activities in female soccer players.

INTRODUCTION
Female soccer players tend to show relatively high incidences of non-contact ACL injuries compared to their male counterparts [2]. A previous study suggested that co-contraction of the hamstrings and quadriceps may play an important role in providing stabilization of the knee joint and potentially protect the ACL during high impact sports activities [1]. Also, it has been speculated that a low level of hamstring activations compared to quadriceps is related to ACL injuries in female athletes [4]. Therefore, the purpose of this study was to investigate the biomechanical factors of ACL injury, including lower extremity muscle activations, and joint kinematics and kinetics at different heights in female soccer players.

METHODS
Ten professional female soccer players who had no lower extremity injury for at last six months prior to the study (age: 23.9±2.4yrs, height: 164.4±3.5cm, body mass: 55.1±6.5kg, career: 11.3±1.3yrs) participated.

Five trials to determine the isokinetic muscle strength of the knee at a speed of 60°/sec were collected using a Humac (CSMI, USA) and averaged. Reference voluntary contraction (RVC) of the lower extremity during drop landing was measured during a biomechanics test, using a wireless electromyography system (Noraxon, USA) with a sampling of 2500 Hz. RVC value (100%) were used in order to compare the levels of activation in the lower extremity muscles between different heights (30cm, 40cm, and 50cm) during drop landing tasks. Eight infrared cameras (Qualysis, Sweden) with a sampling of 250 Hz and two force plates (Kistler, Switzerland) with a sampling of 2500Hz were used to measure three dimensional kinematics and kinetics of the lower extremity during drop landing tasks.

EMG electrodes were attached to three locations; the vastus medialis (VM), the vastus lateralis (VL), and the biceps femoris (BF) of the right leg. The kinematics and kinetics of the right leg including joint angles (°), moment (Nm/kg) and power (W/kg) were analyzed at each event. Figure 1 shows four events (e.g. E1: 50ms before initial contact, E2: initial contact, E3: maximum vertical force, and E4: maximum knee flexion).

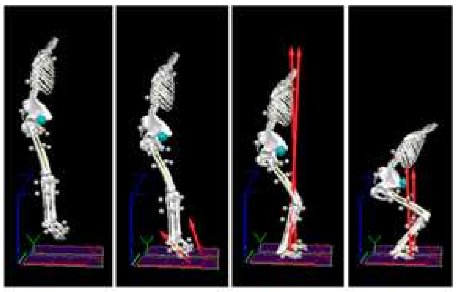

Figure 1: Selected events for the analysis

Participants were asked to jump 10 trials for each height and land with both feet on two separate force plates. Their upper body movement was limited with an arms-crossed position. Repeated ANOVA with Bonferroni post hoc adjustment and pearson correlation coefficients using a statistical software package (SPSS 18.0; Chicago, Illinois; USA) were applied.

RESULTS AND DISCUSSION
This study investigated the differences in biomechanics variables between three different heights when landing. Table 1 shows the comparison of joint kinematics and kinetics at a maximum knee flexion (E3) between the three heights. The magnitude of ground reaction forces were increased as the height was increased. Subjects did not change their flexion angles even when the height was increased. There was a tendency to show an increase in negative joint power in response to an increased jump height. Subjects seem to change their landing strategy due to an increased impact of landing as they tended to increase negative ankle plantar flexion power and negative hip external rotation joint power. Previous studies suggested that an increased negative joint power is related to an increased eccentric work to reduce impact from landing [5]. However, increased negative joint power was only observed at the ankle and hip rather than the knee in this study.

The level of muscle activation tends to rise as the height was increased but it was not statistically significant. From the anatomical perspective, it has been suggested that the increased muscle activation of the hamstrings as a protective mechanism to ACL injury [3]. Thus, this study focused on this role and investigated changes of hamstring activations in response to an increased level of risk. However, no changes in hamstring activation or hamstring activation with respect to quadriceps (HQ ratio) were observed as the height of landing was elevated (Figure 2). Therefore, whether female soccer players activate a high level of HQ ratio as a protective mechanism to avoid ACL injury is still unclear. Future study would be required to attack this research question and this information would be beneficial for the development of more effective injury intervention for female soccer players.

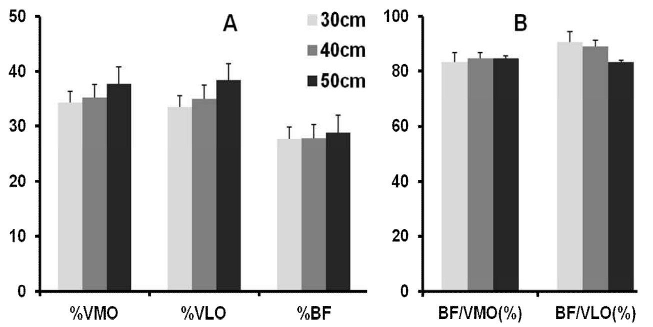

Figure 2: A: Level of muscle activations of VM, VL, and BF, B: BF/VM and BF/VL ratio (%) during the phase between E2 and E3.

On the other hand, there was a positive correlation found between the ratio of hamstring to quadriceps strength during the Humac test and HQ ratio (BF/VM) during drop landing tasks. A significant positive correlation between the ratio of hamstring to quadriceps strength during the Humac test and HQ ratio (BF/VM) during drop landing tasks was found at the phase between initial contact and maximum vertical force during drop landings from a 50 cm height (p = .004) (Figure 3).

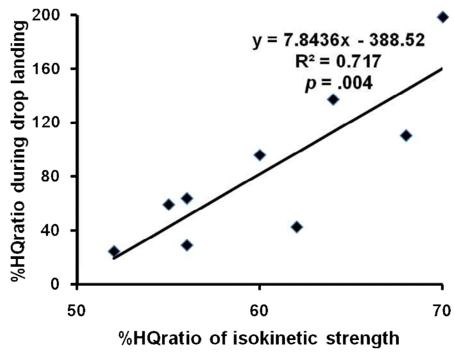

Figure 3: Correlation between the ratio of hamstring to quadriceps strength during the Humac test and HQ ratio during the phase between E 2 and E 3 at 50 cm height of drop landing task (n=9).

CONCLUSIONS

This study was conducted to investigate if female soccer players activate a protective mechanism, such as increasing negative joint power and hamstring activation, in response to an increased risk of ACL injury. The findings showed an increased negative joint power at the ankle and hip but no differences were found in any muscle activations including the hamstrings. However, hamstrings and quadriceps strength ratio from an isokinetic test was positively correlated with HQ ratio during drop landing tasks. These results indicated that strengthening the hamstrings through an exercise program would have a positive impact on preventing ACL injury during sport activities in female soccer players.

ACKNOWLEDGEMENTS

This study was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2011-332-1891).

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Table 1: Comparison of ground reaction forces, kinematics, and kinetics of lower extremity at E 3(at maximum vertical force).

	Variables	30 CM	40 CM	50 CM	F(df)[p]
Ground Reaction Force	Lateral GRF (N/kg)	-1.35(0.51)	-1.21(0.61)	-0.97(0.56)†	17.059(1,9)[0.003]
	Anterior GRF(N/kg)	1.93(0.45)	2.16(0.68)**	2.39(0.71)†	18.496(1,9)[0.002]
	Vertical GRF (N/kg)	17.3(2.75)*	19.1(3.24)**	21.4(3.64)†	29.004(1,9)[0.000]
Ankle	Plantar flexion angle(deg)	101.56(4.34)	102.84(4.56)	103.4(5.83)	2.642(1,9)[0.138]
	Plantar flexion joint power(W/kg)	-7.79(2.55)*	-10.54(3.5)	-12.66(4.18)†	33.240(1,9)[0.000]
Knee	Flexion angle(deg)	-52.91(7.18)	-53.69(7.1)	-53.96(9.18)	.426(1,9)[0.530]
	Valgus moment(Nm/kg)	-0.25(0.16)	-0.26(0.16)	-0.30(0.21)	3.272(1,9)[0.104]
	Flexion joint power(W/kg)	-16.22(3.95)	-18.67(5.52)	-19.82(7.00)	5.004(1,9)[.052]
Hip	Flexion angle(deg)	43.41(8.9)	42.5(7.24)	40.15(8.84)	2.017(1,9)[0.189]
	External rotation moment(Nm/kg)	-0.38(0.16)	-0.41(0.19)	-0.46(0.18)†	15.587(1,9)[0.003]
	Flexion joint power(W/kg)	-5.34(2.22)	-5.94(3.73)	-6.48(3.6)	3.136(1,9)[0.110]

*indicates difference between 30cm-40cm, ** indicates difference between 40cm-50cm, † indicates difference between 30cm-50cm.