INCREASED MUSCLES ACTIVATION COMPENSATES LESS MUSCLE STRENGTH IN MALE NON-JUMPERS DURING LANDINGS

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SUMMARY
The purpose of this study was to examine the difference in muscle activities during landings between male jumpers and non-jumps. Ten male jumpers (track and volleyball athletes) and 10 age, height and mass matched non-jumpers (swimmers) performed step-off landing trials in soft and stiff landing styles from a 60cm height. EMG of Vastus medialis (VM), long head of biceps femoris (BF), medial head of gastrocnemius (MG), and tibialis anterior (TA) were recorded, full-wave rectified, normalized. The non-jumpers had significantly greater aEMG for GA (p=0.027) and BF (p=0.045) compared to the jumpers during landing phase. It was concluded that the non-jumpers preferred to increase muscle activities to compensate for less knee flexors strength.

INTRODUCTION
It has been demonstrated that the knee muscles play an important and consistent role in impact force attenuation during landing activities [1,6], and weaker knee strengths in females is associated with a more erect landing style [1], greater knee extensors activation and less hamstring activation [4], which may contribute to increased female ACL injury. However, our previous data [5] has showed that weaker knee strengths in males non-jumpers (swimmers) is related to a less erect landing style (less knee contact flexion angle and less maximum knee flexion angle) compared to the male jumpers (track and volleyball athletes). It seems that less knee strength in male non-jumpers may not contribute to increased ACL injury risk as showed in female athletes. It is not clear any muscle activation changes occurred in males during landing due to weaker knee strength. Therefore, the purpose of this study was to examine the difference in muscle activities during landings between male jumpers and non-jumps

METHODS
Ten male jumpers (track and volleyball athletes: age 21.0 ± 1.5 years, height 1.85 ± 0.05 m, mass: 72.7 ± 6.8 kg.) and 10 age, height and mass matched non-jumper (swimmers) were recruited. The participants were asked to perform step-off landing trials in two conditions: soft and stiff landing from a 60cm landing height. The maximum knee flexion angles during landings were constrained within $100\text{-}110°$ for soft landings and $65\text{-}75°$ for stiff landings. Surface EMG (1000 Hz, Biovision Inc., Wehrheim,

Germany.) of Vastus medialis (VM), long head of biceps femoris (BF), medial head of gastrocnemius (MG), and tibialis anterior (TA) were recorded during landings. Raw EMG signals were filtered using a band-pass filter with cutoff frequencies of 10 and 400Hz. The signals were then full-wave rectified and filtered using a moving root-mean-squared (RMS) filter with a window size of 50ms. The maximum of the average peak EMG signal of each of the four muscles in functional tests were used to normalize EMG of the respective muscle during the landing trials. The normalized EMG signals were then integrated in two time intervals, from 200 ms prior to contact for pre-landing phase and from contact to maximum knee flexion for landing phase. The integrated EMGs were further divided by the respective time intervals to obtain average EMG (aEMG) values. A 2 (groups) $\times$ 2 (landing styles) mixed design ANOVA was performed to determine any significant effects and interactions of groups and landing styles.

RESULTS AND DISCUSSION
The non-jumpers had significantly greater aEMG for GA (p=0.027) and BF (p=0.045) compared to the jumpers during landing phase (Table1). The aEMG of GA (p=0.001) and BF (p= 0.002) also increased significantly with stiffness. For the pre-landing EMG, only the TA for the jumpers was significantly greater than non-jumpers (p=0.006, Table 3). The BF and VM ratio was significantly increased with stiffness (p=0.043).

A previous study showed that female athletes appear to preferentially rely on increased quadriceps activation, without an increase in hamstrings activation, with increased landing height [3]. While, the present study showed male athletes used different muscle activation patterns. Without an increase in quadriceps activation to compensate for less muscle strength, non-jumpers even increased BF activation with increased landing stiffness. Therefore, greater BF/VM ratios during landing as well as pre-landing phases were observed for the non-jumpers (not significantly different). The co-contraction of agonists and antagonists is considered necessary to maintain joint stability and related to ACL injury [1].

Also, the aEMG of BF was significantly greater for non-jumpers compared to jumpers in both soft and stiff landing styles. These results suggest that the experienced jumpers may have employed a more efficient muscle activation

strategy due to greater knee strength while the non-jumpers preferred to increase muscle activities to compensate for less knee flexor strength. Combined with kinematic data obtained from our previous study [5], it is very reasonable to hypothesize that less knee strengths may not contribute to higher ACL injury risk in males. However, it is unclear whether the increased muscle activities may cause fatigue sooner and eventually contribute to higher ACL injury risk.

CONCLUSIONS

The non-jumpers had significantly greater aEMG for GA and BF compared to the jumpers during landing phase. The non-jumpers preferred to increase muscle activities to compensate for less knee flexors strength.

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Table 1: aEMG of muscles of four landing conditions: mean $\pm$ SD.

Variable	Unit	Non-jumpers		Jumpers	
		Soft	**Stiff**	**Soft**	**Stiff**
$GA_{land}^{\wedge\#}$	(%)	0.19 ± 0.07	0.37 ± 0.14	0.12 ± 0.04	0.23 ± 0.10
$BF_{land}^{\wedge\#}$	(%)	0.67 ± 0.38	0.86 ± 0.32	0.43 ± 0.41	0.55 ± 0.39
$TA_{land}^{\wedge}$	(%)	0.58 ± 0.14	0.58 ± 0.23	0.65 ± 0.17	0.50 ± 0.23
VM_{land}	(%)	1.25 ± 0.43	1.14 ± 0.44	1.02 ± 0.26	1.02 ± 0.58
$(BF/VM)_{land}^{\wedge}$	(%)	0.62 ± 0.29	0.77 ± 0.21	0.46 ± 0.51	0.72 ± 0.80
$TA_{pre}^{\#}$	(%)	0.10 ± 0.07	0.11 ± 0.06	0.22 ± 0.10	0.15 ± 0.08

Note: the subscripts *pre* and *land* represent the durations from 200ms prior to contact to contact and contact to the maximum knee flexion angle, respectively, $^{\wedge}$: significant difference on Stiffness, $^{\#}$: significant difference on Group.