

HAMSTRING MUSCLE ACTIVATION DIFFERENCES BETWEEN GENDERS WHILE PERFORMING SINGLE LEG LANDINGS

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Women are 2-10 times more likely to incur an ACL injury compared to males. Hamstring neuromuscular differences between genders may contribute to genu valgum, a posture that is unfavorable to ACL integrity. The intention of this study was to examine hamstring activation patterns between genders when executing single leg landings. Ten male and ten female recreationally active subjects performed three repetitions of a single leg drop landing onto each leg. Surface EMG data were obtained from the medial and lateral hamstrings. A 2X2X2 repeated measures ANOVA indicated there were no main effects for gender, side, or muscle on the dependent variables ($p > 0.05$). Results of this study suggest that males and females exhibit similar medial/lateral hamstring neuromuscular activation strategies when landing from a jump.

KEYWORDS: anterior cruciate ligament, muscle activation, semi-membranosis, semi-tendinosis.

INTRODUCTION: Females incur a disproportionate rate of non-contact type ACL injuries when compared to their male counterparts (Hewett et al., 2005). Lower extremity neuromuscular mechanisms may be responsible for these injuries. Female athletes have been shown to land with greater dynamic knee valgus during sporting activities. Lower extremity muscle activity during dynamic movements may lead to posturing detrimental to ACL integrity (Myer et al., 2005). The purpose of this study was to examine the medial/lateral activation patterns of the hamstring musculature between genders when performing single leg landings from an elevated position.

METHODS: Ten male and ten female recreationally active college students were recruited from the campus of Northern Michigan University for this study. Subjects were excluded from the study if they reported less than at least 60 minutes of physical activity per week or previous history of lower extremity injury or disorder. Female mean age, height, and weights were; 22.5 ± 4.7 years, 168.75 ± 5.8 cm, and 65.60 ± 8.9 kg respectively. Male mean age, height, and weights were; 24.2 ± 4.0 years, 179.50 ± 10.5 cm, and 77.34 ± 15.0 kg respectively. The use of human subjects was approved by Northern Michigan University's Human Subjects Research Review Committee (# HS08-233). Informed consent forms and a joint pain questionnaire were reviewed and signed by each subject prior to data collection.

This study used bipolar surface electrodes connected to an amplifier (MP 150, BioPac Systems Inc, Goleta, CA) to determine muscle activity when landing from an elevated position. Data were collected at a sample rate of 1000 Hz or a period of 5 seconds. A 10-500 Hz band pass filter was employed. Data were then saved to a personal computer (IBM Thinkpad) for later analysis. Prior to interpretation, the raw electromyography (EMG) data were rectified using the root mean square. The rectified data was then integrated by averaging over every 20 samples. Analysis of this data was performed using AcqKnowledge 3.9.1 (BioPac Systems Inc, Goleta, CA, USA). The electrode sites were prepared by shaving leg hair with a disposable razor, abrading the epidermal skin layer, and swabbing the sites with isopropyl alcohol to reduce impedance of the skin to <5 -kilo ohms ($k\Omega$). Disposable self-adhesive Ag/AgCl snap electrodes (Noraxon, Scottsdale, AZ, USA) were secured, bilaterally, over the muscle bellies of the biceps femoris and semi-tendinosis. The conductive surface of each electrode measured 1 cm, with an inter-electrode distance of 2 centimeters (cm). Ground electrodes were placed bilaterally, over the ipsilateral medial and lateral tibial condyle.

Preceding the landing trials, normalization of EMG data were performed relative to a maximal isometric contraction (MVC) of the hamstring musculature for comparison between the subjects and side (left/right). Subjects were asked to sit on an Isokinetic Dynamometer (Biodex Shirley, NY, USA) with their knees and hips flexed to 90 degrees. EMG data were captured while the participant was encouraged to perform a single leg maximal hamstring isometric contraction for 5 seconds on each lower extremity. Following the MVC's, each subject was allowed to rest while standing for approximately 5 minutes.

A single force plate (OR6-7-2000, AMTI, Watertown, MA, USA) was used in this study to determine the moment of initial contact when landing occurred. Vertical ground reaction forces (VGRF) during the landings were recorded at a sampling rate of 1000 Hz utilizing Netforce 2.0 software (AMTI Watertown, MA, USA). Both EMG and VGRF signals were chronologically synchronized to one signal during data collection for later analysis. Time to peak integrated electromyography (IEMG) for the four muscles was calculated as the time when muscle activity reached peak amplitude following initial contact.

Drop landing trials required the subjects to hang from an elevated position by both hands. A 50 cm multipurpose straight bar was suspended from an adjustable zinc coated chain that was secured to the building structure located directly above the subject. For each subject, the bar was adjusted so that the subject's feet were 33 cm above the force platform while hanging, with the plantar surface of the feet parallel with the force platform. A total of six trials of the landing task were performed (3 onto each leg). When instructed, the subject would release their hands from the straight bar and drop onto the force platform. Landing side (right vs. left) was randomly assigned for each trial. Subjects were asked to maintain balance upon landing to the best of their ability.

The dependent variables observed in this study were time to peak integrated EMG amplitude from initial landing contact, mean integrated EMG amplitudes, and percent MVC for the medial and lateral hamstring (semi-tendinosis and biceps femoris). Means and standard deviations were calculated for the dependent variables. A 2x2x2 (gender x side x muscle) mixed design ANOVA, where the landing side and muscles were repeated measures, was used to evaluate the main effects of each independent variable on biceps femoris muscle activation as well as the main effects on semi-tendinosis muscle activation.

RESULTS: Results revealed no significant differences between men and women for mean IEMG activity following initial contact ($p = 0.412$). No significant differences were found when examining mean IEMG activity after initial contact between side ($p = 0.722$). Mean IEMG activity subsequent to initial contact showed no significant differences between the semi-tendinosis and biceps femoris ($p = 0.252$). A summary of IEMG values are presented in Table 1.

Peak IEMG following initial contact was expressed as a percentage of the subject's MVC. Semi-tendinosis and biceps femoris percent MVC were not shown to be significantly different between males and females ($p = 0.879$). No significant differences were found when examining percent MVC at peak IEMG following initial contact between landing side ($p = 0.959$). The two hamstring muscles examined in this study were shown to not be statistically different when comparing percent MVC of peak IEMG after initial contact ($p = 0.181$). Table 2 shows peak IEMG values.

Time to peak IEMG after initial contact examination between genders confirmed that there was no statistical difference ($p = 0.619$). There were no differences between landing leg when analyzing time to peak IEMG after initial contact ($p = 0.986$). Both the semi-tendinosis and biceps femoris demonstrated peak IEMG activation below the level of significance ($p = 0.696$). Actual time to peak IEMG values are reported in Table 3.

Table 1. Mean IEMG activity shown in volts.

	Mean IEMG Muscle Activation			
	Left Biceps Femoris	Right Biceps Femoris	Left Semi-Tendinosis	Right Semi-Tendinosis
Male	0.01375 ± 0.00867	0.01031 ± 0.00406	0.01404 ± 0.00838	0.01515 ± 0.01045
Female	0.00968 ± 0.00470	0.01002 ± 0.00378	0.01214 ± 0.00441	0.01331 ± 0.00544

Table 2. Peak IEMG shown as % MVC following initial contact.

	Peak IEMG Muscle Activation (% MVC)			
	Left Biceps Femoris	Right Biceps Femoris	Left Semi-Tendinosis	Right Semi-Tendinosis
Male	50.8 ± 33.5	43.0 ± 22.2	49.4 ± 17.5	42.8 ± 20.1
Female	40.5 ± 21.4	47.2 ± 23.0	45.1 ± 13.4	50.3 ± 17.9

Table 3. Time (seconds) from initial contact when landing a jump until peak muscle activity.

	Time-to-Peak Muscle Activation			
	Left Biceps Femoris	Right Biceps Femoris	Left Semi-Tendinosis	Right Semi-Tendinosis
Male	0.4219 ± 0.1357	0.3670 ± 0.1783	0.3653 ± 0.1598	0.3040 ± 0.1360
Female	0.3222 ± 0.2097	0.3591 ± 0.1550	0.2996 ± 0.1907	0.3930 ± 0.1486

DISCUSSION: Disproportionate medial/lateral quadriceps muscle activation differences between genders have been identified, and could potentially explain the ACL injury rate disparity between the genders (Myer et al., 2005). In addition, Subsequent to landing, unbalanced medial/lateral hamstring activation may further jeopardize knee joint positioning. Activation of the lateral hamstrings prior to, or with greater force than that of the medial hamstrings could load the lateral tibio-femoral joint and leave the medial joint line open, leading to genu-valgum, and vulnerable to ACL injury. The combination of medial/lateral muscle activation disparities in both the quadriceps and hamstrings could increase this medial joint line space. The findings of this investigation do not support our hypothesis, suggesting another mechanism may be responsible for the disproportionate ACL injury rate identified between the genders.

Participants from the current study also performed bilateral lower extremity landings to be used for a separate investigation by Abe and coworkers (2009) comparing 3-dimensional (3D) kinematics during single leg and bilateral leg drop landings between genders. While in conflict with the kinematic findings of Chappell and others (2005) females demonstrated greater peak

knee flexion angles during the bilateral landing procedure when compared to their male counterparts, despite a lack of significance. These results suggest that females utilize different landing patterns to attenuate vertical loads when landing with both lower extremities, while both genders may use similar landing postures when landing on a single limb. The comparable knee angles seen with single leg landings in Abe's study may have contributed to the lack of differences in hamstring muscle activity results between genders seen during the current study. The greater knee angle differences noticed between genders during the bilateral leg landings may have equally resulted in different hamstring activity. Further examination is warranted to determine if hamstring activity differs between males and females during bilateral drop landings. A power analysis was performed following the completion of this study to determine if a type II error existed. A beta value of 0.45 was found; indicating that a type II error was possible (Faul et al., 2007). Future studies should utilize a greater number of subjects to minimize the chances of committing a type II error, while attention is directed at examining 3D knee kinematics in conjunction with lower extremity muscle EMG data to establish if females utilize different landing techniques than males, and how these techniques are influenced by muscle activity. The similar hamstring activity found between genders in this study may impact the course of ACL injury prevention strategies. Future research should be conducted to confirm if hamstring activity is similar during bilateral leg landings. This may help rule-out medial/lateral hamstring activation differences as a contributor to the ACL injury rate disparity between genders. Instead, attention should be aimed toward other neuromuscular mechanisms, where gender differences were shown to exist, contributing to dynamic knee valgus (Zazulak et al., 2005).

CONCLUSION: The results of this study suggest that for the muscles studied, males and females possess similar neuromuscular activation strategies when performing single leg landings. These muscles therefore would not produce a gapping of the medial joint line about the knee. It appears that variations in medial/lateral hamstring muscle activation are not a contributor to the ACL injury rate disparity between gender when considering single leg landings. The attention of injury prevention professionals should therefore be directed at other causes of dynamic genu-valgum in recreational active females.

REFERENCES:

- Abe S, Lewis MKD, Malliah K, Malin PL, Jensen RL. (2009) Effect of bilateral or single leg landing on knee kinematics. In *Proceedings of the XXVII Congress of the International Society of Biomechanics in Sport*, (Anderson R, Harrison D, & Kenny I, editors) 488.
- Chappell JD, Creighton A, Giullani C, Yu B, Garrett WE. (2007) Kinematics and electromyography of landing preparation in vertical stop-jump: Risks for noncontact anterior cruciate ligament injury. *Am J Sports Med*, 35(2), 235-241.
- Faul F, Erdfelder E, Lang AG, Buchner A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, 39, 175-191.
- Hewett TE, Myers GD, Ford KR, Heidt RS, Colosimo AJ, McLean SG, vanden Bogert AJ, Paterno MV. (2005). Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes. *Am J Sports Med*, 33(4), 492-501.
- Myer GD, Ford KR, Hewett TE. (2005) The effect of gender on quadriceps muscle activation strategies during a maneuver that mimics a high ACL injury risk position. *J Electromyography Kinesiol*, 15(2),181-189.
- Oatis CA. (2004) *Kinesiology: The Mechanics and Pathomechanics of Human Movement*. Philadelphia, PA: Lippincott, Williams and Wilkins, p. 724.
- Zazulak BT, Ponce PL, Straub SJ, Medvecky MJ, Avedisian L, Hewett TE. (2005) Gender comparison of hip muscle activity during single-leg landing. *J Orthop Sport Phys*, 35(5), 292-299.