Quadriceps to Hamstrings Coactivation Ratios During Closed Chain, High Velocity Exercise in Healthy, Recreationally Active Adults

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Background

The anterior cruciate ligament (ACL) has been reported as one of the most commonly injured ligaments of the knee. A high incidence of ACL injuries are non-contact injuries that occur during high velocity, closed chain movements and quick changes in motion, such as accelerating, decelerating, cutting, and pivoting (Noyes & Barber-Westin, 2012). There is current literature regarding quadriceps to hamstrings (Q:H) coactivation ratios during closed chain, low velocity exercises and on open chain isokinetics. There was no literature found in sport specific high velocity exercises, which are utilized in training and rehabilitation. Understanding theses ratios maybe more useful in having a better understanding of the dynamic stability of the knee joint and its surrounding structures for prevention and return to sport ability..

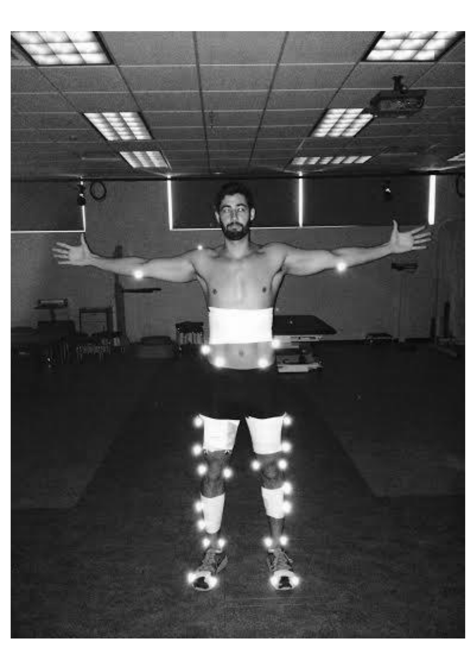
Research Questions

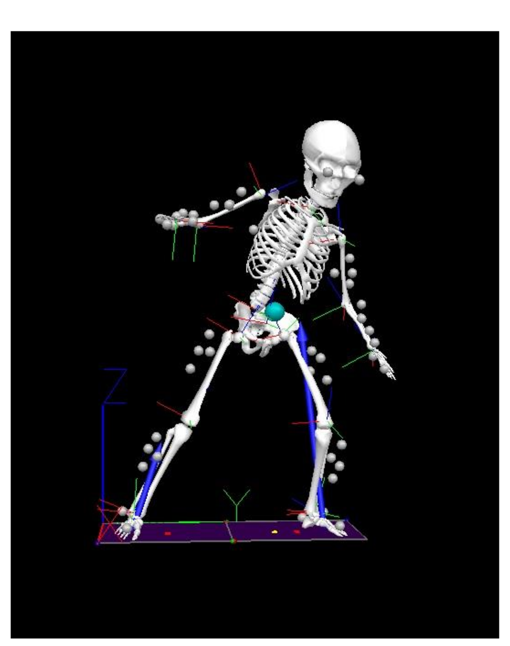
1. What are the Q:H coactivation ratios during closed chain, high velocity exercises including squat jump, barrier jump side to side, barrier jump front to back, scissor jump, and lateral bounding in recreationally active adults?

2. At what angle of knee flexion does the maximum EMG activity occur of the vastus medialis (VM), vastus lateralis (VL), medial hamstrings (MH), and biceps femoris (BF)?

Subjects

Convenience sampling was utilized to recruit 20 healthy recreationally active college students (12 men, 8 women) between the ages of 18-30 years old at Florida Gulf Coast University.





Methods

Collect MVIC data of selected muscle groups utilizing Noraxon surface EMG → Qualisys Motion Analysis markers placed on bony prominences of subjects → Subjects performed eight repetitions of five selected exercises → Coactivation ratios calculated from subject's data

$$(VM+VL)/(MH+BF)=Q{:}H \text{ coactivation ratio}$$

Barrier Jump Front to Back

Barrier Jump Side to Side

Lateral Bounding

Scissor Jump

Squat Jump

Data Analysis

1. ANOVA was utilized to identify differences in Q:H coactivation ratios among exercises. In addition a multivariate analysis was used to identify the effect of jump between subjects.

2. ANOVA was utilized to identify differences in peak muscle activity for each of the four muscles during all five exercises. In addition, a multivariate analysis to identify the effect of jump on peak EMG flexion angle.

Table 1. Calculated Quadriceps: Hamstrings Co-activation Ratios for Each Plyometric Exercise (Max ± SD)

Exercise	Q:H Co-activation Ratio
Barrier Front to Back: Max	5.05±7.33
Barrier Side to Side: Max	4.51±5.29
Bounding: Max	3.08±2.61
Scissor: Max	4.10±3.24
Squat Jump: Max	3.70±3.02

Multivariate Tests

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Pillai's trace	.529	3.651[a]	4.000	13.000	.033	.529
Wilks' lambda	.471	3.651[a]	4.000	13.000	.033	.529
Hotelling's trace	1.123	3.651[a]	4.000	13.000	.033	.529
Roy's largest root	1.123	3.651[a]	4.000	13.000	.033	.529

Each F tests the multivariate effect of jump. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

Pairwise Comparisons

(I) jump	(J) jump	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	.481	.565	.407	-.716	1.678
	3	1.862	1.773	.309	-1.896	5.620
	4	.792	1.358	.568	-2.086	3.671
	5	1.168	1.742	.512	-2.525	4.861
2	1	-.481	.565	.407	-1.678	.716
	3	1.381	1.256	.288	-1.283	4.044
	4	.311	.826	.711	-1.440	2.062
	5	.687	1.214	.579	-1.886	3.260
3	1	-1.862	1.773	.309	-5.620	1.896
	2	-1.381	1.256	.288	-4.044	1.283
	4	-1.069*	.503	.049	-2.135	-.004
	5	-.694*	.280	.025	-1.288	-.100
4	1	-.792	1.358	.568	-3.671	2.086
	2	-.311	.826	.711	-2.062	1.440
	3	1.069*	.503	.049	.004	2.135
	5	.376	.500	.464	-.685	1.437
5	1	-1.168	1.742	.512	-4.861	2.525
	2	-.687	1.214	.579	-3.260	1.886
	3	.694*	.280	.025	.100	1.288
	4	-.376	.500	.464	-1.437	.685

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Results

- Statistically significant differences (p<0.05) were found between the Q:H ratios of lateral bounding and the scissor jump and between lateral bounding and the squat jump.
- There was a statistically significant difference (p<0.001) in vastus lateralis activation during lateral bounding when compared to the other four exercises.
- There was a statistically significant difference (p<0.05) in peak flexion medial hamstrings activation during bounding when compared to the barrier jump front to back, barrier jump side to side, and the scissor jump.
- There was a statistically significant difference (p<0.05) in peak flexion biceps femoris activation for lateral bounding when compared to barrier jump side to side, scissor jump, and squat jump.
- There was a statistically significant difference (p<0.05) between the flexion angle of the medial hamstrings compared to the other muscles. The peak EMG flexion angle (58.94˚) for the medial hamstrings was significantly larger than the biceps femoris, vastus lateralis, and vastus medialis.

Conclusion

- The barrier jump front to back, barrier jump side to side, and scissor jump facilitate earlier activation of the hamstrings in relation to the quadriceps suggesting that these exercises provide the most stability to the posterior aspect of the knee, thus protecting the ACL.
- In contrast, lateral bounding facilitates earlier quadriceps activation and therefore should be used with caution in the early stages of ACL rehabilitation due to the anterior shear force placed on the ACL from the quadriceps.
- In conclusion, having knowledge of both the overall Q:H ratios as well as the timing of peak muscle contraction allows for better exercise prescription and progression and could also be used for injury prevention programs.

Clinical Relevance

This study identified exercises that facilitate hamstring activation and stabilization, as well as exercises that should be used with caution during ACL rehabilitation. Clinicians can use the results of this study to guide their exercise prescription with the ACL rehabilitation and prevention population along with a better understanding of return to sport activities.