

SYSTEMATIC REVIEW

EXERCISES THAT FACILITATE OPTIMAL HAMSTRING AND QUADRICEPS CO-ACTIVATION TO HELP DECREASE ACL INJURY RISK IN HEALTHY FEMALES: A SYSTEMATIC REVIEW OF THE LITERATURE.

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ABSTRACT

Background: Anterior cruciate ligament (ACL) injury is common among females due to many anatomic, hormonal, and neuromuscular risk factors. One modifiable risk factor that places females at increased risk of ACL injury is a poor hamstrings: quadriceps (H:Q) co-activation ratio, which should be 0.6 or greater in order to decrease the stress placed on the ACL. Exercises that produce more quadriceps dominant muscle activation can add to the tension placed upon the ACL, potentially increasing the risk of ACL injury.

Hypothesis/Purpose: The purpose of this systematic review was to compare quadriceps and hamstring muscle activation during common closed kinetic chain therapeutic exercises in healthy female knees to determine what exercises are able to produce adequate H:Q co-activation ratios.

Study Design: Systematic Review

Methods: Multiple online databases were systematically searched and screened for inclusion. Eight articles were identified for inclusion. Data on mean electromyography (EMG) activation of both quadriceps and hamstring muscles, % maximal voluntary isometric contraction (MVIC), and H:Q co-activation ratios were extracted from the studies. Quality assessment was performed on all included studies.

Results: Exercises analyzed in the studies included variations of the double leg squat, variations of the single leg squat, lateral step-up, Fitter, Stairmaster® (Core Health and Fitness, Vancouver, WA), and slide board. All exercises, except the squat machine with posterior support at the level of the scapula and feet placed 50 cm in front of the hips, produced higher quadriceps muscle activation compared to hamstring muscle activation.

Conclusion: Overall, two leg squats demonstrate poor H:Q co-activation ratios. Single leg exercises, when performed between 30 and 90 degrees of knee flexion, produce adequate H:Q ratios, thereby potentially reducing the risk of tensile stress on the ACL and ACL injury.

Level of Evidence: 2a- Systematic Review of Cohort Studies

Key words: Anterior cruciate ligament, electromyography, hamstrings, quadriceps, resistance training

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28. maximal voluntary isometric contraction[Text Word]
29. maximum voluntary isometric contraction[Text Word]
30. 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29
31. resistance training[MeSH Terms]
32. resistance training[Text Word]
33. therapeutic exercise[Text Word]
34. muscle strengthening[Text Word]
35. exercise therapy[MeSH Terms]
36. exercise therapy[Text Word]
37. physical therapy[Text Word]
38. physiotherapy[Text Word]
39. exercise[MeSH Terms]
40. open chain kinetic exercise[Text Word]
41. closed chain kinetic exercise[Text Word]
42. 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41
43. 5 AND 11 AND 30 AND 42

CINAHL Search Strategy

1. (MH "Hamstring Muscles") OR "hamstrings" OR "hamstring" OR "hamstring muscle" OR "hamstrings muscle"
2. (MH "Quadriceps Muscles + ") OR "quadriceps" OR "quadricep" OR "quadricep muscle" OR "quadriceps muscle"
3. (MH "Electromyography") OR "electromyography" OR "EMG" OR "muscle activation" OR "neuromuscular activation" OR "co-activation" OR "coactivation" OR "co-recruitment" OR "corecruitment" OR "co-contraction" OR "cocontraction" OR "h/q" OR "h/q ratio" OR "MVIC" OR "Maximal voluntary isometric contraction" OR "maximum voluntary isometric contraction"
4. (MH "Resistance Training") OR "resistance training" OR (MH "Therapeutic Exercise") OR "therapeutic exercise" OR (MH "Closed Kinetic Chain Exercises") OR (MH "Lower Extremity Exercises") OR (MH "Muscle Strengthening + ") OR "muscle strengthening" OR (MH "Open

Kinetic Chain Exercises") OR "exercise therapy" OR (MH "Physical Therapy") OR "Physical therapy" OR "physiotherapy" OR (MH "Exercise") OR "closed kinetic chain" OR "closed chain" OR "open kinetic chain" OR "open chain"

5. 1 AND 2 AND 3 AND 4

Web of Science Search Strategy

1. TOPIC: (hamstrings) OR TOPIC: (hamstring) OR TOPIC: (hamstring muscle) OR TOPIC: (hamstrings muscle)
2. TOPIC: (quadriceps) OR TOPIC: (quadricep) OR TOPIC: (quadriceps muscle) OR TOPIC: (quadricep muscle)
3. TOPIC: (electromyography) OR TOPIC: (EMG) OR TOPIC: (muscle activation) OR TOPIC: (neuromuscular activation) OR TOPIC: (co-activation) OR TOPIC: (coactivation) OR TOPIC: (co-recruitment) OR TOPIC: (corecruitment) OR TOPIC: (co-contraction) OR TOPIC:(cocontraction) OR TOPIC: (h/q) OR TOPIC: (h/q ratio) OR TOPIC: (h/q activation) OR TOPIC: (h/q coactivation) OR TOPIC: (MVIC) OR TOPIC: (maximum voluntary isometric contraction) OR TOPIC: (maximal voluntary isometric contraction)
4. TOPIC: (resistance training) OR TOPIC: (therapeutic exercise) OR TOPIC: (muscle strengthening) OR TOPIC: (exercise therapy) OR TOPIC:(physical therapy) OR TOPIC: (physiotherapy) OR TOPIC: (exercise) OR TOPIC: (closed chain kinetic exercise) OR TOPIC: (open chain kinetic exercise)
5. 1 AND 2 AND 3 AND 4

Scopus Search Strategy

1. ((TITLE-ABS-KEY (quadriceps*)) OR (TITLE-ABS-KEY (quadriceps femoris*)) OR (TITLE-ABS-KEY (quads*)) OR (TITLE-ABS-KEY (quad*)) OR (TITLE-ABS-KEY (quadricep*)))
2. ((TITLE-ABS-KEY (hamstrings*)) OR (TITLE-ABS-KEY (hamstring*)))
3. ((TITLE-ABS-KEY (resistance training) OR TITLE-ABS-KEY (open chain kinetic exercise) OR TITLE-ABS-KEY (closed chain kinetic exercise) OR TITLE-ABS-KEY (therapeutic

- exercise) OR TITLE-ABS-KEY (lower extremity exercise) OR TITLE-ABS-KEY (muscle strengthening) OR TITLE-ABS-KEY (neuromuscular facilitation) OR TITLE-ABS-KEY (plyometrics) OR TITLE-ABS-KEY (exercise therapy) OR TITLE-ABS-KEY (physical therapy) OR TITLE-ABS-KEY (physiotherapy) OR TITLE-ABS-KEY (neuromuscular activation)))
4. ((TITLE-ABS-KEY (electromyography) OR TITLE-ABS-KEY (emg) OR TITLE-ABS-KEY (electromyography feedback)))
 5. 1 AND 2 AND 3 AND 4

PEDro Search Strategy

1. Knee EMG

SportDiscus Search Strategy

1. DE "QUADRICEPS muscle" OR DE "RECTUS femoris muscle" OR DE "VASTUS medialis"
2. DE "HAMSTRING muscle"
3. H/Q
4. H/Q ratio
5. H/Q activation
6. H/Q coactivation
7. DE "ELECTROMYOGRAPHY"
8. maximal voluntary isometric contraction
9. maximum voluntary isometric contraction
10. mvic
11. EMG
12. Muscle activation
13. Neuromuscular activation
14. Co-activation
15. Coactivation
16. Co-recruitment
17. Corecruitment

18. Co-contraction
19. Cocontraction
20. 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19
21. DE "EXERCISE" OR DE "AEROBIC exercises" OR DE "ANAEROBIC exercises" OR DE "AQUATIC exercises" OR DE "BUTTOCKS exercises" OR DE "CALISTHENICS" OR DE "CHAIR exercises" OR DE "CIRCUIT training" OR DE "EXERCISE for children" OR DE "EXERCISE for girls" OR DE "EXERCISE for men" OR DE "EXERCISE for middle-aged persons" OR DE "EXERCISE for women" OR DE "EXERCISE for youth" OR DE "EXERCISE therapy" OR DE "FOOT exercises" OR DE "GYMNASTICS" OR DE "HIP exercises" OR DE "ISOKINETIC exercise" OR DE "ISOLATION exercises" OR DE "ISOMETRIC exercise" OR DE "ISOTONIC exercise" OR DE "KNEE exercises" OR DE "LEG exercises" OR DE "MUSCLE strength" OR DE "STRENGTH training"
22. closed kinetic chain
23. closed chain
24. open kinetic chain exercises
25. open kinetic chain
26. open chain
27. therapeutic exercise
28. muscle strengthening
29. DE "PHYSICAL therapy"
30. Physical therapy
31. physiotherapy
32. 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31
33. 1 AND 2 AND 20 AND 32