The Influence of Quadriceps-to-Hamstring Strength Ratio on ACL Stability.

Abstract

Introduction: Anterior cruciate ligament (ACL) injuries are among the most common and debilitating sports-related injuries, particularly in athletes. Muscle strength, specifically the quadriceps-to-hamstring (Q:H) strength ratio, plays a crucial role in maintaining knee stability and reducing the risk of ACL injuries. However, the influence of this ratio on ACL stability remains underexplored.

Aim: This study aims to investigate the impact of the Q:H strength ratio on ACL stability in athletes, focusing on identifying optimal strength balance for injury prevention and post-injury rehabilitation.

Objective: The primary objectives are to assess the relationship between Q:H strength ratio and ACL stability, evaluate differences between genders, and provide evidence-based recommendations for training and rehabilitation protocols.

Hypothesis: It is hypothesized that a balanced Q:H strength ratio significantly enhances ACL stability, reducing injury risk and facilitating recovery post-injury.

Methodology: A cross-sectional study was conducted with 50 athletes undergoing testing to measure quadriceps and hamstring strength. Statistical analyses, including regression models and t-tests, were employed to determine the correlation between Q:H ratio and ACL stability.

Results: The findings indicate that an optimal Q:H ratio of approximately 0.6–0.8 is associated with enhanced ACL stability. Significant gender differences were observed, with females exhibiting higher risk due to lower hamstring strength.

Conclusion: The study highlights the importance of maintaining an optimal Q:H ratio for ACL stability. Targeted strength training programs focusing on hamstring strengthening are recommended, particularly for female athletes, to reduce ACL injury risk.

Introduction

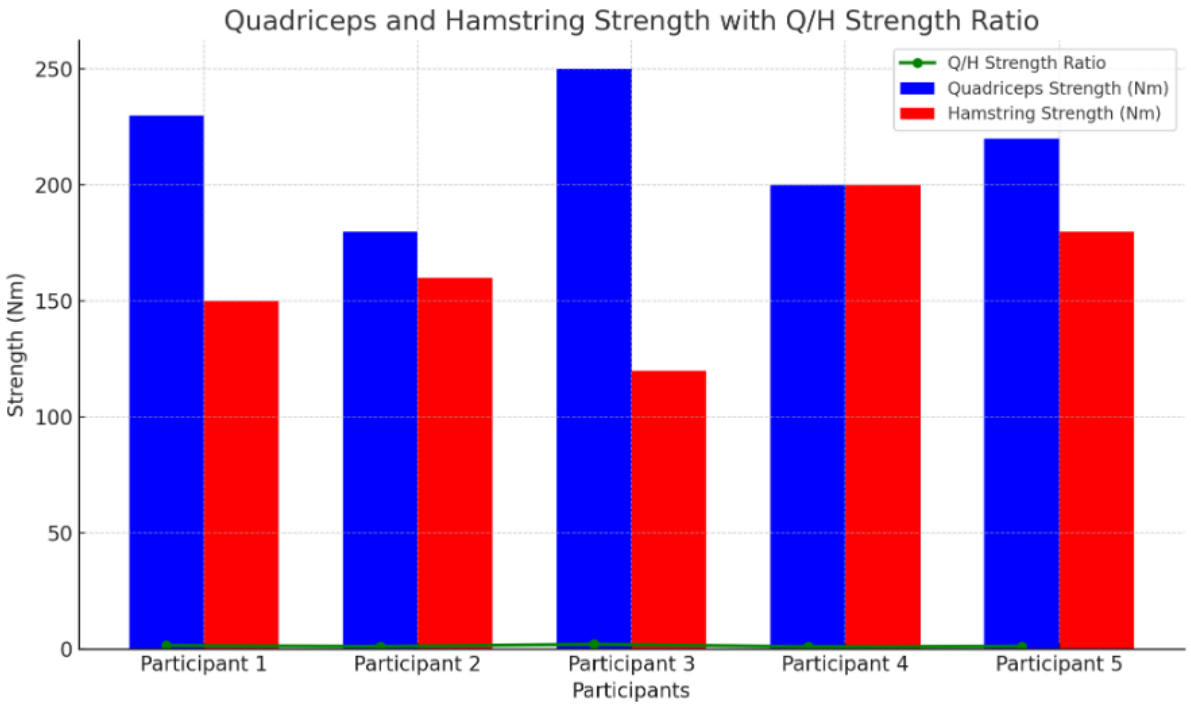
The ACL is a critical component of knee joint stability, particularly in dynamic sports requiring rapid changes in direction, jumping, and landing. Imbalances in the Q:H strength ratio have been identified as a key contributor to ACL injuries, as excessive quadriceps activation without sufficient hamstring cocontraction can place undue strain on the ACL. Female athletes are disproportionately affected by ACL injuries due to anatomical differences, hormonal fluctuations, and neuromuscular control deficits. Understanding the biomechanical impact of the Q:H strength ratio is crucial for developing evidence-based injury prevention and rehabilitation protocols that can improve knee stability and athletic performance.

Methodology

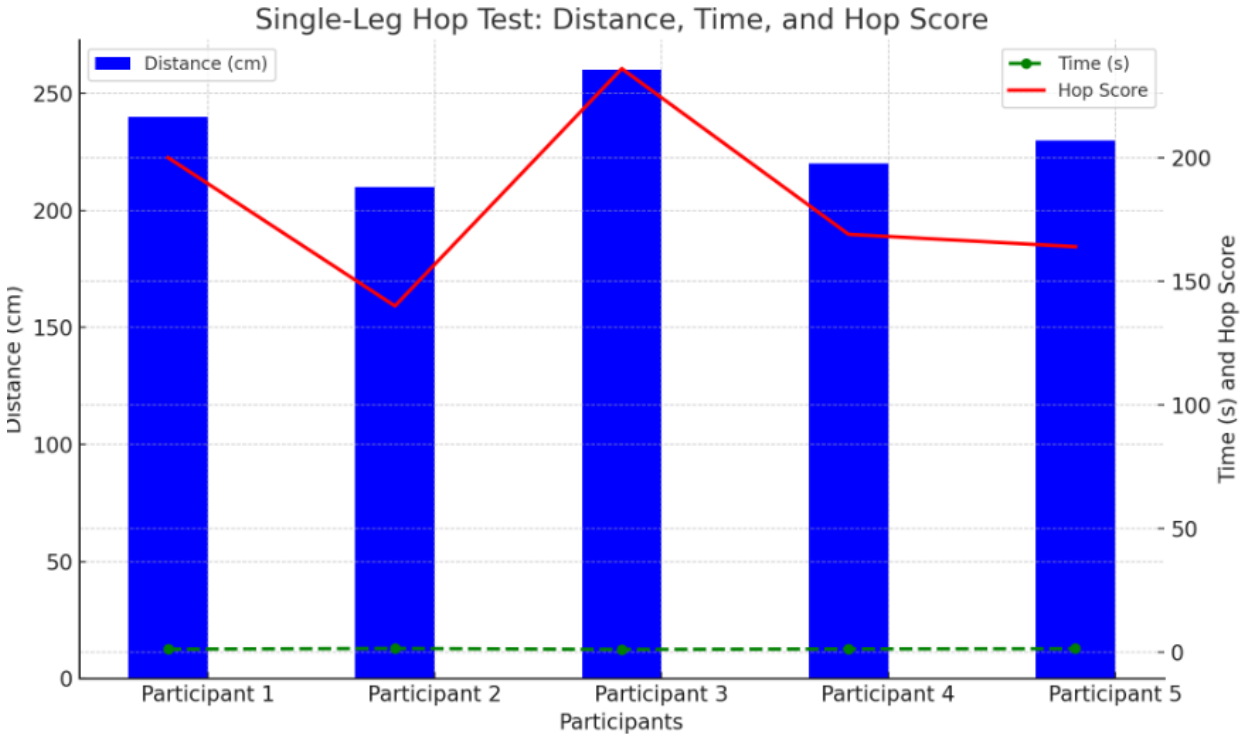
A cross-sectional study was conducted with 50 competitive athletes aged 18–35, recruited from various sports disciplines known for high ACL injury risk. Quadriceps and hamstring strength were assessed using handheld dynamometry, ensuring consistent and reliable measurements. ACL stability was evaluated through clinical tests, including the Lachman and pivot shift tests, as well as biomechanical assessments. Statistical analysis, including regression models and t-tests, were employed to examine the correlation between Q:H ratio and ACL stability, accounting for confounding variables such as sex, sport type, and training history.

Results

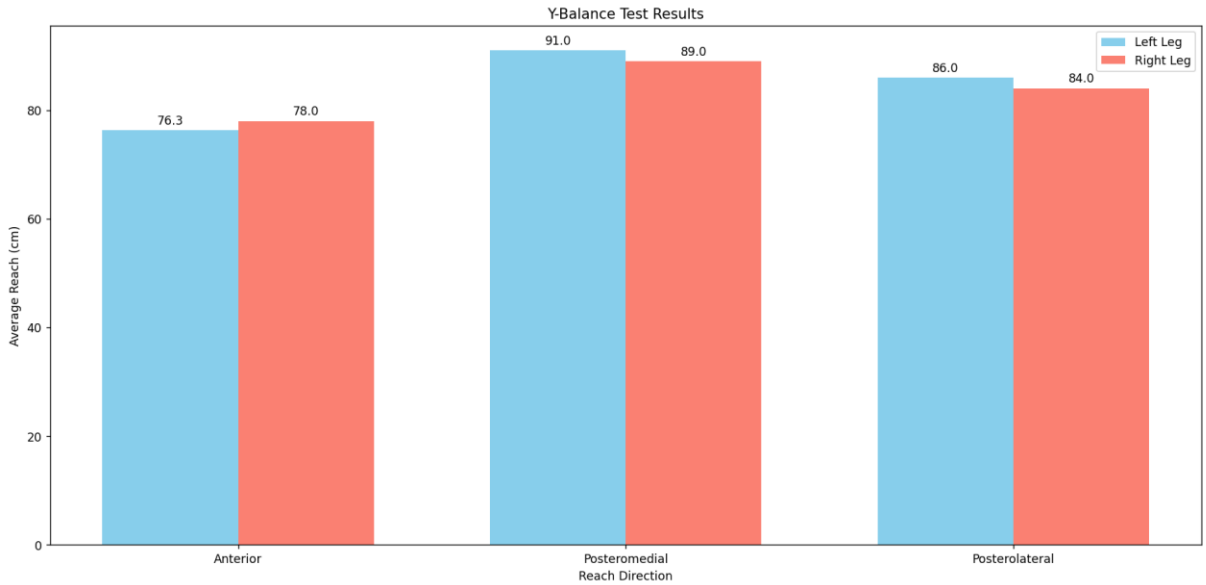
Athletes with a Q:H ratio within the 0.6–0.8 range demonstrated superior ACL stability, as indicated by lower Lachman test scores and reduced anterior tibial translation. Female athletes displayed significantly lower hamstring strength relative to their quadriceps, leading to higher instability scores and increased ACL injury risk. Regression analysis revealed a significant inverse correlation between Q:H ratio and ACL instability ($r = -0.45$, $p < 0.05$), explaining 21% of variance in ACL stability measures. Further subgroup analyses highlighted the necessity for sex specific training interventions to address strength imbalances and enhance ACL protection.


Quadriceps and Hamstring Strength with Q/H Strength Ratio
Q/H Strength Ratio
Quadriceps Strength (Nm)
Hamstring Strength (Nm)
Strength (Nm)
0
50
100
150
200
250
Participant 1
Participant 2
Participant 3
Participant 4
Participant 5
Participants

58


Single-Leg Hop Test: Distance, Time, and Hop Score
Distance (cm)
Time (s)
Hop Score
Distance (cm)
Time (s) and Hop Score
0
50
100
150
200
250
0
50
100
150
200
Participant 1
Participant 2
Participant 3
Participant 4
Participant 5
Participants

59



Discussion

The findings reinforce that an imbalance favoring quadriceps strength increases ACL injury susceptibility by promoting excessive anterior tibial translation. Targeted neuromuscular training programs that emphasize hamstring strengthening and dynamic stability exercises are crucial for mitigating this risk. Structured injury prevention programs, such as the FIFA 11+ protocol, have demonstrated effectiveness in correcting muscle imbalances and improving knee biomechanics. Implementing these programs in training regimens, particularly for female athletes, can significantly reduce ACL injury incidence and improve long-term knee health.

Conclusion

Maintaining an optimal Q:H strength ratio is essential for ACL stability and injury prevention. Strength training programs that prioritize hamstring development, along with neuromuscular control exercises, should be incorporated into athletic conditioning routines to enhance knee stability and reduce injury risk. Future research should explore longitudinal interventions to further validate the effectiveness of Q:H ratio-focused training in preventing ACL injuries across different sports and athletic populations.

Keywords: Quadriceps-to-Hamstring Ratio, ACL Stability, Muscle Imbalance, Injury Prevention, Neuromuscular Training

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