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Original Research

A Comparison of Quadriceps-to-Hamstrings Ratios During Isokinetic Testing, Cutting, and Drop Landings in Male Soccer Players

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ABSTRACT

International Journal of Exercise Science 13(4): 157-166, 2020. Collegiate soccer is not an unusual place to suffer a knee injury. The sport has many dynamic movements, such as cutting, jumping and shooting. Many professionals use quadriceps-to-hamstring (Q/H) ratios as a tool to determine when an injured player can to return to game play or use the ratio to investigate how predisposed a certain player is to sustaining a knee injury. However, many of these ratios are taken in isokinetic testing in a controlled environment and to our knowledge it is unknown if these ratios are similar to those measured during dynamic activity. Therefore, this study investigated if there was a relationship between Q/H ratios measured during isokinetic testing and drop landings and cutting. Fifteen Division 2 collegiate male soccer players (age: 19.79 ± 1.25 years; height: 176.74 ± 6.22 cm; weight: 77.24 ± 11.01 kg). Wearing Athlos© compression shorts participants performed isokinetic testing, drop landings and cutting drills while muscle activity was measured. A significant difference was found between the bilateral Q/H ratios during the drop landings ($p = 0.04$; $\eta = 0.49$). There were no significant bilateral differences measured during the cutting drills in either direction and isokinetic testing ($p > 0.05$). Additionally, there was so significant relationship in Q/H ratios between isokinetic testing and the dynamic movements ($p > 0.05$). This suggests that clinicians should use Q/H ratios during dynamic movements rather than isokinetic testing in a controlled environment to better assess player risk disposition and return-to-play criteria.

KEY WORDS: Functional movement, knee, lower extremity, strength ratios

INTRODUCTION

Soccer is a popular collegiate sport with approximately 24,800 male student-athletes (www.ncaa.org). Because the sport involves running, sprinting, jumping, and quick directional changes, injuries are a common occurrence. Knee injuries are especially relevant for male soccer players due to the nature of the sport. Previously, it was determined that approximately 24% of all soccer injuries occur at the knee (13). While there has been a significant decrease in the number of injuries (15), the incidence of knee injuries is still relatively high with up to 19% occurring during competition (22).

The cause of these injuries is varied, but approximately 59% have been reported to be non-contact injuries (9), Specifically, running, shooting, turning, and jumping causes up to 39% of all injuries, with landing accounting for 4% of those injuries (10). While the incidence may be fairly low, landing injuries can be particularly debilitating as the movement results in large torques, stress, and force on the lower extremity. Additionally, incorrect landing technique can increase the risk of injury to the player. Because some of the most common injuries are to the muscles or ligaments, the muscles surrounding these structures may play a role in these injuries. If the surrounding tissues aren't supportive of these injured structures, it would lead to failure due to overstressing. Therefore, active management of lower extremity muscular balance could potentially lead to less sprains and strains.

The quadriceps-to-hamstrings ratio (Q/H) is an indicator of lower-extremity muscle balance. It is also an indicator of potential injury. Recently, it was determined that a Q/H ratio less than 1.8 (H/Q less than 0.55) was associated with increased injury risk in professional soccer players (5). Additionally, Grooms et al. (8) determined that there was a reduction in in-season injuries as a result of correcting ratio imbalances. Q/H ratios are also used in return-to-play (RTP) scenarios after injury. A recent systematic review determined that RTP has various definitions, but concluded that returning to the athlete's pre-injury level and performing full sport activities were the most important factors. This makes strength testing a key factor in pre-season training.

Interestingly, the focus has been on Q/H strength ratios, which has been found to be a weak risk factor for injury and not bilateral imbalances. A 4-year cohort study determined that there were small absolute strength differences with a wide overlap of strength measurements between soccer players that were injured and those that were not (21). This infers that focusing on the Q/H strength ratios may not be beneficial to the athletes for injury prevention. Croisier et al. (5) previously determined that injuries occurred as a result of strength imbalances compared to those that had no strength imbalances, bilaterally. The relative risk of 4.66 was significantly higher for those with bilateral strength imbalances and remained high even after training to correct the imbalance (relative risk = 2.89).

Isokinetic testing is commonly used to measure Q/H ratios and bilateral differences. However, it was previously determined that there were no bilateral isokinetic differences in the Q/H ratios in male collegiate soccer players (18), leaving one to speculate that Q/H ratios do not play a significant role in injuries. It should be addressed, though, that one drawback is that the testing typically occurs on an isokinetic dynamometer in a controlled environment while the injuries occur in an uncontrolled environment on the field. Therefore, it is possible that Q/H ratios are significant factors in injuries. But because they are typically performed in a controlled environment, researchers are unable to capture the true ratios and imbalances that may be present during functional activities, leaving athletes at risk for injury. In fact, it was determined that isokinetic muscle testing was not able to determine athletes who were predisposed to injury compared to those who were not (3). Therefore, the purpose of the present study was to determine whether there was a relationship between isokinetic Q/H ratios and Q/H ratios performed during drop landings and agility cutting drills. Additionally, we investigated whether there were any functional imbalances present during the drop landings and agility cutting drills that would predispose the athletes to injury.

METHODS

Participants

Participants were 15 Division 2 collegiate male soccer players between the ages of 18 and 44 years old. Participant demographics are presented in Table 1. They were currently in their off-season and trained at least three times per week. Additionally, they were free of any lower extremity injuries or surgeries within the past 6 months and any cardiovascular disease within the past year. All participants provided written informed consent prior to participation and the Institutional Review Board at Loyola Marymount University approved the protocol. Additionally, this research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (16).

Table 1. Participant demographics (n = 15).

	Height (cm)	Weight (kg)	Age (yr)
Subject	176.74 ± 6.22	77.24 ± 11.01	19.79 ± 1.25

Note: Data presented as mean ± standard deviation; cm = centimeters; kg = kilograms; yr = years.

Protocol

Research personnel randomized the order of exercise testing to assign an order of either isokinetic testing first or functional movements first using blocked randomization to minimize a training effect. Subjects were asked to abstain from exercise 24 hours prior to testing. Additionally, participants were allowed to rest between each of the conditions, so the influence of fatigue was minimized. The entire exercise testing session lasted approximately one hour for each participant.

After completing the informed consent and healthy history questionnaire, height to the nearest 0.01 cm and weight to the nearest 0.1 kg were measured using a calibrated stadiometer and scale, respectively. Body composition was measured by bioelectrical impedance analysis (Omron HBF-306; Omron Healthcare Inc, USA). Participants were then given a pair of Athos© compression garments of the correct size to change into with bare skin underneath. The compression shorts had EMG sensors woven into the fabric in specific anatomical locations, including the inner and outer quad, as well as the biceps femoris. Participants then completed a standardized warm-up on a cycle ergometer (Monark 828E; Monark Exercise AB, Sweden) for approximately five minutes. Subsequently, participants randomly performed isokinetic testing and the functional movements (cutting and drop landings; described below) in a counterbalanced fashion.

Isokinetic Testing: All of the participants were taken through isokinetic testing protocol using an isokinetic dynamometer (HUMAC Norm; Computer Sports Medicine Inc., USA). Once warm-up was complete, the Athos© compression garments were calibrated using the Athos© app and maximal voluntary muscle contraction testing performed by the research team. Briefly, to calibrate the quadriceps, while sitting the participants were asked to kick out and extend their knee while a researcher applied resistance. For the hamstrings, the participants were asked to stand next to a wall and hold their arms out to it for support while kicking back and flexing their knee with a researcher applying resistance. The participants were then placed in the dynamometer, where the protocol was explained to them by the clinician. Isokinetic testing occurred through maximal effort from the participant while velocity was controlled by the dynamometer. The dynamometer was adjusted to subject-specific settings for maximum comfort and reduced-risk of injury. During testing, participants were required to flex and extend their knee against a resistance at 60, 90, 180 and 240 degrees/second. Participants performed five (5) repetitions for each velocity, with one minute of rest in between each velocity. This protocol was then repeated on the opposite leg.

Drop Landings: Once the warm-up was completed, participants performed three countermovement vertical jumps to measure their maximal vertical jump height. Using a vertical jump trainer (Vertec; Jump USA, USA), participants were asked to stand with their feet approximately hip-to-shoulder width apart and perform a maximal vertical jump with a countermovement arm swing. Three maximal vertical jumps were performed with approximately one minute of rest between each jump. The highest of the three jumps was recorded and used to set their drop landing height. A box equal to their maximal vertical jump height was placed in front of a force plate (AMTI BP600600; Advanced Mechanical Technology, USA) They were then instructed to allow their preferred leg to hoover over the force plate and lean forward until they must remove their standing leg from the box to reduce jumping off the box. Participants were then instructed to land with both feet completely in the force plate and allow their knees to slightly bend before returning to standing. Participants were allowed to practice prior to recording of data. They conducted five trials of drop landings which were recorded.

Cutting Drill: Participants were asked to do a five-meter sprint forward before performing a 45-degree cut to the left or right following a route marked on the floor with tape. They were instructed to plant their foot on the ‘x’ in the middle of the force plate and cut to either direction. This was accomplished by planting the opposite foot on the force platform. For example, when cutting to the left, participants were asked to plant their right foot on the force platform then cut at 45 degrees to the left, and vice versa. Participants were able to stop after accelerating for 3 steps in the instructed direction. Participants were given several practice attempts to correctly perform the movement prior to data collection. They performed 5 trials in each direction, and the order of the directions (i.e. left or right first) was counterbalanced among the participants.

Q/H Ratios: Quadriceps-to-hamstrings ratios were measured via electromyography (EMG) measurements which were taken from Athos© compression garments. The shorts were made of 75% Nylon and 25% Lycra® Spandex and contained EMG sensors sewn into the fabric of the shorts in specific anatomical locations. The apparel was previously validated against surface EMG for muscle activity measurements (2). Each participant was sized based on the company recommendations and the comfort of the participant. The warm-up on the cycle ergometer was used to begin to collect sweat from the participant to ensure good contact with the electrodes was achieved. Data were collected via an application during the isokinetic testing and drop landings. Each speed of isokinetic testing as well as each individual drop landing and cutting drill data were collected as a separate trial.

Statistical Analysis

The Athos© application presented Q/H ratios in the interface for each trial (CV = 19.9-28.7). The trials were averaged together for each condition (isokinetic, cutting left, cutting right, and drop landings) to obtain an overall Q/H ratio for each exercise condition as well as averaged bilaterally (for the left and right leg, separately). For the isokinetic testing, data from the 180 degrees/sec trials were used as the input variables as this was previously determined to be a velocity that was the most accurate predictor of functional ability (12). A Pearson's correlation analysis was run to determine if there was any relationship among the average Q/H ratios of each condition. A paired T-test was used to determine the differences in the mean Q/H ratios of the left and right legs during each condition. Effect size was calculated according to Cohen's d by calculating the mean difference between the left and right Q/H ratios, and then dividing by the pooled standard deviation for each condition: (M1 – M2)/ SD. The alpha level was set at 0.05.

RESULTS

A significant difference was found between the right and left leg Q/H ratios during the drop landings (p = 0.04; η = 0.49; t = -2.40; Figure 1). Specifically, the Q/H ratio of the right leg was 32.39% greater compared to the left leg. There was no significant difference between the left and right legs during the cutting drills in either direction and isokinetic testing (p > 0.05; t = -1.40; Figure 1).

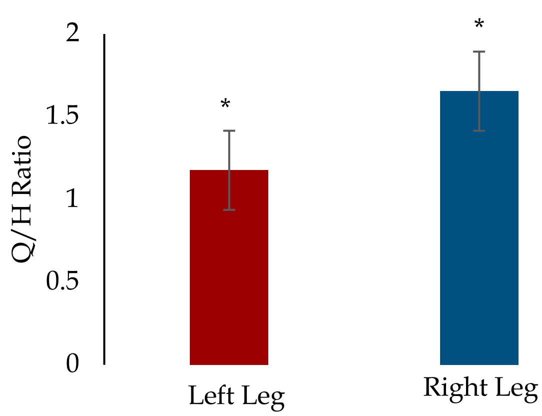

Figure 1A. Bilateral Q/H ratios during drop landings.

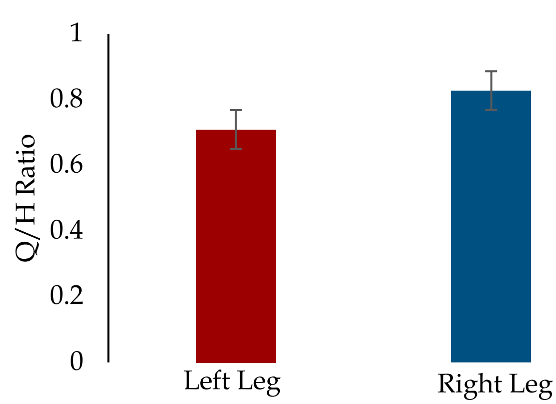

Figure 1B. Bilateral Q/H ratios during cutting to the left.

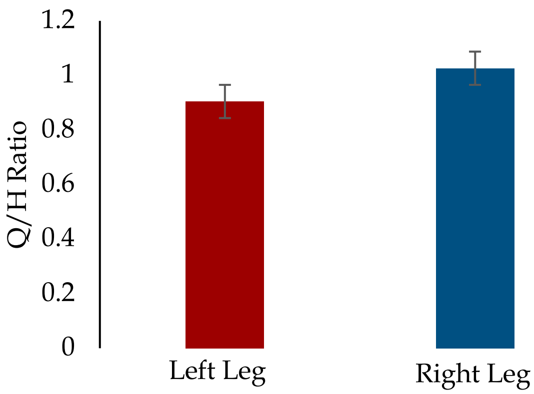

Figure 1C. Bilateral Q/H ratios during cutting to the right.

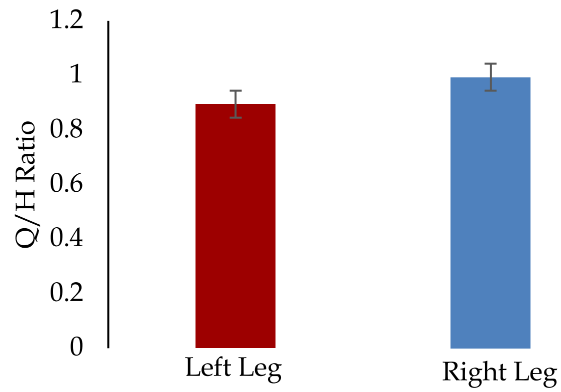

Figure 1D. Bilateral Q/H ratios during isokinetic testing.

A significant correlation was found between cutting left and cutting right (r = 0.9, p <0.001; Figure 2), cutting left and drop landings (r = 0.75, p = 0.008; Figure 2), and cutting right and drop landings (r = 0.82, p = 0.002; Figure 2). There was no significant relationship between the average Q/H ratio during isokinetic testing and any other condition (p > 0.05).

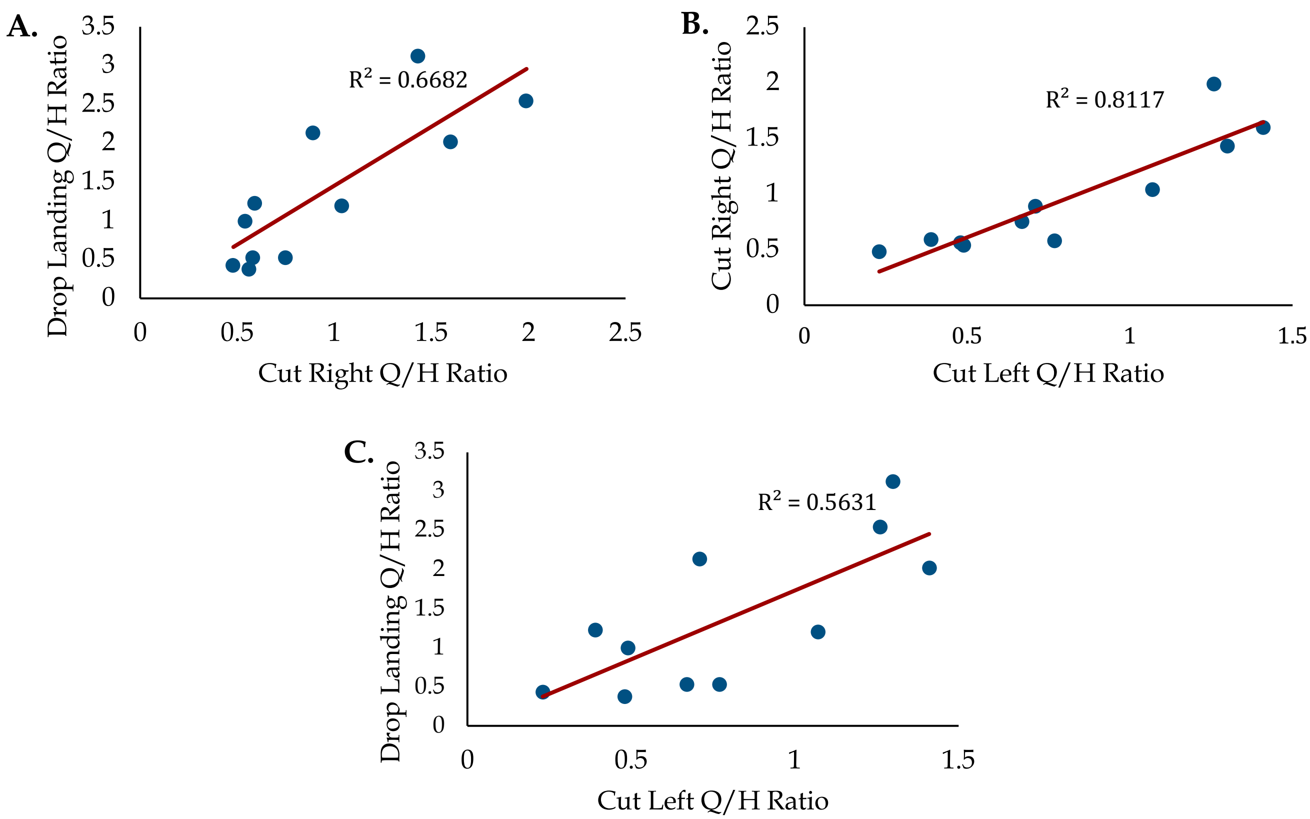

Figure 2. Correlation plots of Q/H ratios during: (A) cutting to the left and the right; (B) cutting to the left and drop landings; and (C) cutting to the right and drop landings. All correlations were significant at 0.05.

DISCUSSION

The primary purpose of the present study was to determine if there was an association between Q/H ratios measured during isokinetic testing and functional movement drills in male soccer players. Additionally, we sought out to determine if there was a significant difference between the right and left Q/H ratios during each condition. To our knowledge, we are among the first to determine that there was no significant relationship between the average Q/H ratios measured during isokinetic testing and functional movement drills in male soccer players. We also determined that bilateral differences were only seen during drop landings. Together these results could have potential implications for injury risk and return-to-play measures.

The present study determined that there was no significant correlation between Q/H ratios measured in isokinetic testing, and the drop landing and cutting drills. However, when the functional drills were compared to each other, there was a significant correlation among the movements. Specifically, there was a significant correlation between Q/H ratios during cutting both directions when compared jointly, and a significant correlation between drop landings Q/H ratio when compared to the Q/H ratios during cutting both directions. This particular finding is surprising as one would speculate that Q/H ratios measured during isokinetic testing would have a strong relationship to the Q/H ratios measured during functional movements. It is possible that the conventional ratios (concentric quadriceps to concentric hamstrings) we measured during isokinetic testing do not translate to on-field movements due to differing muscle activation patterns during functional movements. Use of a functional H/Q ratio (eccentric hamstring to concentric quadriceps) better describes the agonist-antagonist strength relationship during many sport activities and the knee joint stability (1). Nevertheless, the measurement should have some relationship pattern with the other functional movements, which was not seen in the present study. This could indicate that conventional isokinetic testing cannot reveal those who may be at risk of sustaining an on-field injury. Both cutting and landings pose high intensity impact on the knee in several directions and can lead to strain of soft tissues within the knee if the structure is not properly supported. Therefore, it would make sense to measure Q/H ratios during functional movements and use those for injury predisposition and return-to-play criteria.

Bilateral strength differences have been determined to be a risk factor for injury (5, 7). In the present study, there was a significant bilateral difference in Q/H ratio during drop landings, but not for the cutting drills or isokinetic testing This shows a potential disconnect between agility drills as testing predisposition of injury and isokinetic testing as injury predisposition testing. We speculate that the reason drop landings produced different, bilateral Q/H ratios is due to the nature of athletes to load one leg more than the other. Britto et al. (4) determined that during a drop landing task, recreational athletes load their preferred leg more compared to their non-preferred leg. However, this may prove detrimental as recently it was established that the non-preferred leg presents greater injury risk during landings as a result of increased knee abduction moments and more laterally directed frontal plane GRF vector compared to the dominant leg (19). This could explain injuries that occur as a result of landing from a header or trying to block a shot (goal keeper).

The lack of bilateral asymmetry during cutting and isokinetic testing was not surprising. Previously, it has been demonstrated that soccer players do not display bilateral asymmetries during isokinetic testing (6, 14) at various speeds. However, this raises the issue of the use of isokinetic testing in determining injury risk and return-to-play standards since it appears isokinetic testing may not measure true differences due to its reduced functionality. Currently, there is no clear consensus on return-to-play standards for injuries (18), although "reaching the athlete's pre-injury level" and "being able to perform full sport activities" are some of the primary categories that are used. Typically, isokinetic testing is used in making injury predisposition assessment and return-to-play decisions (3). We suggest that in the future, return-to-play standards do not include isokinetic testing due to the difference in movement and muscle activation patterns between isokinetic testing and simulated on-field movements.

Limitations: There are several limitations that should be noted. The sample population was only male. Therefore, generalizations to female soccer players should be limited and done with caution. We did not reach our observed power of 0.80, likely as a result of small sample size. *Post hoc* analysis based on our calculated effects sizes determined that we needed 35 to reach our target power. This would explain some lack of significance in bilateral differences during the cutting drills as they appeared to be trending towards significance. Future research should reach that minimum number of participants to reach significance. Participants performed the entire protocol in a single day. This potentially may have led to fatigue; however, the participants were trained athletes and the protocol only called for maximum exertion during the isokinetic testing, which allowed for adequate rest. Therefore, we do not believe that fatigue could have played a significant role in the results measured.

Conclusion: It appears that Q/H ratios are most useful for assessing injury predisposition in multidirectional dynamic movements using EMG measurements during the movements and not isokinetic testing. Because of the controlled environment of isokinetic testing, when comparing Q/H ratios bilaterally, the measurements do not sufficiently assess an athlete's injury predisposition. Given the strong correlations present in this study, there is a potential that drop landings and agility testing Q/H ratios may prove to be a better indicator of injury predisposition in soccer athletes.

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