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# Bilateral Knee Joint Isokinetic Muscle Strength and Angle Specific Balance Ratio in Soccer Players

## *Bilaterale isokinetische Muskelkraft des Kniegelenks und des winkelspezifischen Gleichgewichtsverhältnisses bei Fußballspielern*

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## *Summary*

› **Problem Statement:** The aim of the study was to compare the angle-specific torque value and the peak torque values of isokinetic knee strength in both lower extremities in extension and flexion phases at different angular velocities between male and female soccer players and to determine whether there is a difference between the genders.

› **Methods:** 26 female and male professional football players were included. The knee strengths of both lower extremities of the participants were evaluated using isokinetic dynamometry at 60°/sec and 180°/sec. The peak torque (PT) (Newton meters, Nm), body mass-normalized PT (Nm/kg), and H/Q ratios (%), angle-specific ratio (ASR) at 30° and bilateral strength deficit of the quadriceps and hamstring muscles were recorded for the dominant and non-dominant legs.

› **Results:** There was no significant difference in H/Q ratio and ASR between the sexes. There was a moderate correlation between H/Q ratio and ASR. Female players presented significantly higher bilateral deficits for flexor muscles in both angular velocities ($p<0.05$).

› **Discussion:** The results of the study can be summarized as follows: H/Q ratio depends on angular velocity in isokinetic strength testing; compared to men athletes, female athletes have a higher tendency towards asymmetry; and there is a positive correlation between the H/Q ratio and ASR values.

› **Conclusion:** The H/Q ratio is different at various knee flexion angles and future studies should investigate if these approaches are better to identify risc factors.

## *Zusammenfassung*

› **Problemstellung:** Ziel der Studie war es, den winkelspezifischen Drehmomentwert und die Spitzendrehmomentwerte der isokinetischen Kniekraft in beiden unteren Extremitäten in der Extensions- und Flexionsphase bei verschiedenen Winkelgeschwindigkeiten zwischen männlichen und weiblichen Fußballspielern zu vergleichen und festzustellen, ob es einen Unterschied zwischen den Geschlechtern gibt.

› **Methodik:** 26 weibliche und männliche Profi-Fußballspieler wurden einbezogen. Die Kniestärken beider unterer Extremitäten der Teilnehmer wurde mittels isokinetischer Dynamometrie bei 60°/sec und 180°/sec bewertet. Das Spitzendrehmoment (PT) (Newtonmeter, Nm), das körpergewichtsnormierte PT (Nm/kg) und die H/Q-Verhältnis (%), das winkelspezifische Verhältnis (ASR) bei 30° und das bilaterale Kraftdefizit der Quadrizeps- und Kniesehnenmuskeln für das dominante und das nicht-dominante Bein erfasst.

› **Ergebnisse:** Es gab keinen signifikanten Unterschied im H/Q-Verhältnis und im ASR zwischen den Geschlechtern ($p>0{,}05$). Es bestand eine moderate Korrelation zwischen dem H/Q-Verhältnis und der ASR. Spielerinnen zeighten bei beiden Winkelgeschwindigkeiten signifikant höhere bilaterale Defizite für die Beugemuskeln auf ($p<0{,}05$).

› **Diskussion:** Die Ergebnisse der Studie lassen sich wie folgt zusammenfassen: Das H/Q-Verhältnis hängt von der Winkelgeschwindigkeit bei isokinetischen Krafttests ab; Im Vergleich zu männlichen Athleten haben weibliche Athleten eine höhere Neigung zur Asymmetrie; und es besteht eine positive Korrelation zwischen dem H/Q-Verhältnis und den ASR-Werten.

› **Schlussfolgerungen:** Das H/Q-Verhältnis bei verschiedenen Kniebeugungswinkeln unterschiedlich und künftige Studien sollten untersuchen, ob diese Ansätze besser geeignet sind, Risikofaktoren zu identifizieren.

KEY WORDS:
**H/Q Ratio, Angle-Specific Torque, Value, Elite Soccer Players, Peak Torque, Isokinetic Dynamometry**

SCHLÜSSELWÖRTER:
**H/Q-Verhältnis, winkelspezifischer Drehmomentwert, Elite-Fußballspieler, Spitzendrehmomentwert, isokinetischer Dynamometrie**



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## Introduction

Football is the most widely played popular sport in the world in which high-intensity physical activity (such as sprints in various directions, consecutive accelerations and decelerations, sudden turns, repetitive jumps, duels and hitting the ball) requires aerobic endurance and anaerobic power. This type of movement is mostly dependent on the strength of the lower extremity and its neuromuscular structure (3, 7). The maximum strength produced by the muscle groups and the strengthes of the muscle groups that enable different movements to be made on the same joint can be measured objectively with isokinetic dynamometers (21). Evaluation of the resulting strength not only provides an objective assessment between muscle groups but also helps to predict potential injury risk occurrences (20). The quadriceps

Table 1

The demographic and characteristic data of the soccer players. *p<0.05, significant difference. BMI: Body mass index.

| VARIABLES | ATHLETES (N=52) | MALE ATHLETES (N=26) | FEMALE ATHLETES (N=26) | P* |
|---|---|---|---|---|
| Age (years) | 22.60±4.27 | 21.85±4.16 | 23.35±4.33 | 0.195 |
| | 21.5 (17.0-32.0) | 21.0 (17.0-32.0) | 22.0 (17.0-31.0) | |
| Body mass (kg) | 66.10±11.28 | 74.96±7.43 | 57.23±6.39 | 0.535 |
| Height (cm) | 172.94±10.21 | 181.96±5.60 | 163.92±3.39 | 0.007 |
| BMI (kg/m) | 21.96±2.23 | 22.63±2.00 | 21.29±2.28 | 0.687 |
| Dominant leg right | 43 (82.7%) | 18 (69.2%) | 25 (96.2%) | 0.024 |
| Dominant leg left | 9 (17.3%) | 8 (30.8%) | 1(3.8%) | |

muscle plays an important role in hitting and jumping, while the hamstring muscle provides control of running movements. The contraction strength of the quadriceps muscle during knee extension causes the tibia to slide forward relative to the femur. This can be prevented not only by the anterior cruciate ligament (ACL) but also by hamstring activation. Moreover, co-activation of the hamstrings and quadriceps prevents anterior shear on the tibia and protects against knee abduction and dynamic valgus of the lower extremity. Thus, it reduces the risk of injury by decreasing the risk of femoral condyles rising from the tibial plateau. Asymmetrical strength for the lower extremity can be defined as the inability of both the right and left quadriceps and hamstring muscles to produce an equal amount of force in similar types of contraction. The ability to protect the knee from injury is largely dependent on the strength of the hamstring relative to the quadriceps. It has been reported that a hamstring/quadriceps (H/Q) strength ratio of less than 60% and more than 10-15% of muscle strength asymmetry is associated with lower extremity injuries. In addition, maintaining the strength ratio between the agonist and antagonist muscles in the lower extremities has an important place in both the prevention of sports injuries and the elimination of losses that may occur in athletic performance (8, 9, 10, 15, 16, 18, 19, 22).

A high incidence of knee injuries has been reported in sports games that require intense physical activity, such as football. Therefore, it is important to evaluate potential physiological risk indicators to prevent or reduce the occurrence of serious knee injuries in athletes engaged in high-risk sports. Hamstrings-to-quadriceps (H/Q) peak torque ratio has long been used to measure muscle imbalance, rehabilitation and physical conditioning, as quadriceps activation with relative weakness of the hamstrings plays an important role in the pathomechanism of knee injuries. An imbalance in the H/Q peak torque ratio measured with an isokinetic dynamometer has been shown to be associated with a higher incidence of lower extremity injury. The typical H/Q peak torque ratio of a healthy knee ranges from 50 to 80% depending on knee angle and angular velocity. It is generally accepted that an isokinetic H/Q peak torque ratio of 60% or more is desirable in rehabilitation. H/Q peak torque ratios differ by sex, as males and females have a different development of muscle strength during puberty. Males develop a significant increase in the peak torque of the hamstrings during maturity, while in females the peak torque of the hamstrings remains constant during maturation. This marked hamstring weakness creates an imbalance of muscle strength in women's knees. In some of the previous studies, it has been shown that the H/Q peak torque ratios of men and women differ at low isokinetic angular velocities, and in some at high isokinetic angular velocities (1, 16, 23, 25). Moreover, the link between peak torque strength ratio and knee injury is controversial, particularly when the strength is evaluated using an isokinetic dynamometer in soccer players. It has been shown no prevision of knee injury by the knee muscle strength measurements (5, 14). This ratio is insufficient to indicate the sensitivity of the strength to changes in angle or how the strength is maintained over a predetermined angular range. In soccer players, the peak torque of the extensor muscles has been reported as 70º (from full extension), whereas the peak torque of the flexor muscles has been reported as 30-35º. This lack of angular overlap has led to the development and use of angle-specific torque data in addition to the H/Q peak torque ratios. Considering the increased risk of muscle and ligament injury at extended knee joint angles, a hamstring to quadriceps torque ratio close to 30º has been proposed as a better way to assess knee stability and knee injury risk factor (2, 4, 6, 11, 12, 13, 17, 24). Therefore, the aim of this study is to compare the angle-specific torque value and H/Q peak torque values at different angular velocities between male and female soccer players and to determine whether there is a difference between the genders.

## Material and Methods

### Study Design

This study was directed at the Department of Physical Medicine and Rehabilitation in Bezmialem Vakif University. The trial protocol was confirmed by the Ethical Committee of Bezmialem Vakif University (Trial Registration:2022/272). Written consent was acquired by each patient enrolled.

### Participitants and Data Extraction

A sample size and power calculation determined that 12 patients in each group and total of 24 patients would provide sufficient power (power of 0.80, $\alpha$=0.05, and $\beta$=0.20; p≤0.05). The calculation of sample size was based on a mean difference (8.4) and standard deviation (4.3) in the quadriceps muscle strength value according to the previous data (Reference 25) using the PASS (power analysis and sample size) system.

26 female and 26 male professional football players between the ages of 17-31 were included in the study. All athletes were evaluated before the season. Participants continued their regular training programs but were asked to avoid strenuous workouts the day before the test. The current study was conducted following an 8-week pre-season schedule. All participants had no history of pain, discomfort, or any instability during testing. There were also no musculoskeletal knee injuries at the time of testing or within 1 year prior to data collection. Moreover, the participants had no history of lower extremity fractures or surgery during the year prior to the study. Athletes with a history of ACL injury and/or associated operation were excluded from the study.

Table 2

Absolute (Nm) and normalized peak torque (Nm/kg) values of isokinetic concentric strength of the knee flexor (H) and extensor (Q) muscles for the dominant and non-dominant legs in male and female soccer players. *p<0.05, significant difference.

| MUSCLE STRENGTH | MALE | FEMALE | P* | MALE | FEMALE | P* |
|---|---|---|---|---|---|---|
| | DOMINANT | DOMINANT | | NON-DOMINANT | NON-DOMINANT | |
| **Q 60°/sec (Nm)** | 205.69±29.57<br>210.5<br>(161.0-274.0) | 132.54±21.75<br>129.5<br>(99.0-193.0) | <0.001 | 204.31±27.19 | 125.0±27.39 | <0.001 |
| **Q 60°/sec (Nm/kg)** | 260.49±66.24<br>277.0<br>(27.7-355.0) | 233.23±34.73<br>233.5<br>(170.0-316.0) | 0.002 | 268.69±38.05 | 220.23±45.07 | <0.001 |
| **Q 180°/sec (Nm)** | 120.31±20.94<br>117.5<br>(91.0-170.0) | 80.62±17.37<br>76.5<br>(54.0-130.0) | <0.001 | 118.12±25.87<br>122.5<br>(18.0-155.0) | 77.96±16.99<br>75.0<br>(53.0-129.0) | <0.001 |
| **Q 180°/sec (Nm/kg)** | 160.77±25.07 | 140.69±24.59 | 0.005 | 161.42±41.11<br>159.5<br>(27.0-264.0) | 136.77±24.52<br>137.0<br>(95.0-185.0) | 0.003 |
| **H 60°/sec (Nm)** | 119.88±19.64<br>113.5<br>(81.0-160.0) | 72.81±14.41<br>70.0<br>(52.0-107.0) | <0.001 | 111.62±17.92 | 72.35±14.06 | <0.001 |
| **H 60°/sec (Nm/kg)** | 165.92±32.52<br>162.5<br>(101.0-274.0) | 128.0±24.90<br>123.5<br>(86.0-182.0) | <0.001 | 150.12±26.70 | 126.96±22.78 | 0.001 |
| **H 180°/sec (Nm)** | 79.27±13.53 | 49.23±10.35 | <0.001 | 69.85±16.04<br>72.0<br>(12.0-88.0) | 46.19±9.04<br>46.5<br>(31.0-71.0) | <0.001 |
| **H 180°/sec (Nm/kg)** | 106.88±21.05<br>108.5<br>(69.0-143.0) | 86.81±18.11<br>81.5<br>(63.0-119.0) | 0.002 | 93.19±22.83<br>99.5<br>(21.0-128.0) | 81.15±14.99<br>80.0<br>(51.0-122.0) | 0.009 |

The dominant knee was determined by asking the participants which limb they preferred to use while hitting the ball. Before the test, the participants performed warm-up exercises for 5 minutes followed by low-intensity dynamic stretching exercises for the hamstrings and quadriceps. After warm-up, participants were informed about the test protocols to be applied. Then, data including gender, age, height, weight and body mass index (BMI) measurements were recorded. The isokinetic knee strengths of both lower extremities of the participants were evaluated using isokinetic dynanometry (Cybex Humac Norm Testing and Rehabilitation System, CSMI, USA). All tests were performed in a sitting position with the hip and knee flexed at 90 degrees. Gravity correction was performed for each lower extremity prior to testing to reduce the risk of uncertainty. Participants initially performed 3 repetitions on both legs at 60°/sec to familiarize themselves with the device and warm up. Then, they performed the same movement for 5 maximal repetitions. Afterwards, the same operations were applied at 180°/sec. In order to prevent fatigue, a 45-second rest period was given between measurements. The maximum concentric peak torque of the quadriceps and hamstring muscles was measured in the 0° (full extension) and 90° flexion range of motion of the knee joint in a sitting position with the knee and hip angle at 90°. All tests were done by the same examiner. All participants were always encouraged in the same way by the same examiner and struggled likewise to do the exercise. As a result of the test, the isokinetic peak torque (PT) (Newton meters, Nm), body mass-normalized peak torque (Nm/kg), H/Q peak torque ratios (%), torque at 30º (torque measured at 30 degrees of range of motion) (Nm) at 60º/sec, and bilateral strength deficit (%) of the quadriceps and hamstring muscles were recorded for the dominant and non-dominant legs. Athletes with a H/Q peak torque ratio of less than 60% were classified with knee muscle imbalance. Muscle strength asymmetry was calculated as (dominant limb peak torque - non-dominant limb peak torque / dominant limb peak torque) x 100. Athletes with a bilateral strength deficit greater than 15% were classified as asymmetrical. Moreover, the angle-specific balance ratio (ASR) was calculated as torque at 30º of the flexor muscles / torque at 30º of the extensor muscles.

### Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 28.0. Armonk, NY: IBM Corp. Shapiro-Wilk tests were used to assess the assumption of normality. Continuous variables were presented with mean±standard deviation (SD) and median (minimum-maximum). Categorical data were expressed as frequencies with percentage. Categorical variables analyzed with Fisher's exact test. Normal distributions of continuous variables were assessed by independent samples t test. Non-normally distributed metric variables were analysed by Mann–Whitney U tests. Correlations between va-

Table 3

The H/Q ratio and ASR for dominant and non-dominant leg in male and female soccer players. *p<0.05, significant difference. ASR: Angle specific ratio.

| VARIABLES | MALE DOMINANT | FEMALE DOMINANT | P* | MALE NON-DOMINANT | FEMALE NON-DOMINANT | P* |
|---|---|---|---|---|---|---|
| H/Q ratio at 60°/sec | 58.62±7.38 | 55.27±7.67 | 0.115 | 56.08±7.29<br>56.5 (40.0-70.0) | 58.77±9.34<br>56.0 (46.0-87.0) | 0.533 |
| H/Q ratio at 180°/sec | 66.27±13.49 | 61.96±10.19 | 0.200 | 60.04±9.99 | 61.08±11.09 | 0.724 |
| ASR at 30° at 60°/sec | 84.50±7.73 | 81.81±8.87 | 0.249 | 81.81±8.91 | 84.69±9.23 | 0.257 |

Table 4

Correlations between H/Q ratio and angle specific torque (AST) at 30°/sec and gender. *p<0.05, significant difference. +Spearman's correlation coefficient; #Pearson's correlation coefficient.

| VARIABLES | MALE | FEMALE | P* VALUE | AST | |
|---|---|---|---|---|---|
| | | | | R | P* |
| H/Q ratio ≥%60 at 60°/sec (dominant) | 13 (%50) | 6 (%23.1) | 0.044 | 0.595# | <0.001 |
| H/Q ratio ≥%60 at 60°/sec (non-dominant) | 8 (%30.8) | 10 (%38.5) | 0.560 | 0.584+ | <0.001 |
| H/Q ratio ≥%60 at 180°/sec (dominant) | 18 (%69.2) | 17 (%65.4) | 0.768 | 0.403# | 0.003 |
| H/Q ratio ≥%60 at 60°/sec (non-dominant) | 14 (%53.8) | 17 (%65.4) | 0.397 | 0.507# | <0.001 |

riables were assessed using either Pearson's correlation coefficient or Spearman's correlation coefficient tests, which are appropriate. p-value < 0.05 was considered as statistically significant. Type-I error rate was taken $\alpha=0.05$.

## Results

The mean age was 22.60±4.27 years in the study. The mean BMI was 21.96±2.23 (kg/m$^2$). The demographic characteristics of patients were presented in table 1. Isokinetic peak torques (Nm) and peak torques normalized to body mass (Nm/kg) were given in table 2.

Female players presented significantly lower peak torque values of the knee flexor and extensor muscles than male players for the dominant and dominant legs at 60°/sec and 180°/sec (p<0.001). Also, female players presented significantly lower peak torque values of the knee flexor and extensor muscles than male players for the non-dominant limb at 60°/sec and 180°/sec (p<0.001). Moreover, male players presented significantly higher peak torque values normalized to body mass of the knee flexor and extensor muscles than female players for the dominant and dominant legs at 60°/sec and 180°/sec (p<0.05). Male players also presented significantly higher peak torque values normalized to body mass of the knee flexor and extensor muscles than female players for the non-dominant limb at 60°/sec and 180°/sec (p<0.05) (table 2).

There was no significant difference in H/Q ratio between the sexes in both angular velocities for the dominant and non-dominant legs (p>0.05). There also was no significant difference in ASR between the sexes (p>0.05) (table 3). When we categorized the H/Q ratio as ≥60%, there was a statistically significant moderate positive correlation in both the dominant and non-dominant legs at both 60°/sec and 180°/sec. When we categorized the H/Q ratio as ≥60%, there was a statistically significant difference between male and female athletes only at 60°/sec in the dominant leg (p=0.044), but not in the others (table 4). Moreover, there was no significant difference in terms of bilateral strength deficit between the sexes in both angular velocities for extensor muscles (p>0.05), whereas female players presented significantly higher bilateral deficits for flexor muscles in both angular velocities (p<0.05) (table 5).

## Discussion

An athlete's quadriceps and hamstring muscle strength is a prominent part of the athlete's functional capacity and conduces significantly to lower extremity biomechanics and performance. Isokinetic muscle strength tests have been used for many years to evaluate quadriceps and hamstring muscle strength in both athletic and non-athletic populations. It has been shown that female athletes differ in quadriceps and hamstring muscle strength compared to their age- and activity-matched male peers, thus putting them at an increased risk for lower extremity musculoskeletal injuries (23). Predicted risk factors for knee injuries include decreased hamstring-quadriceps (H/Q) strength ratio, bilateral strength deficits, and muscle weakness. Although it has been shown that a decrease in the H/Q peak torque ratio is associated with a high incidence of lower extremity injuries, it has been suggested that muscle weakness and bilateral lower extremity muscle strength deficiencies affect posture, sports performance, and increase hamstring stretch rate (9). This study was conducted to determine the effect of gender and angular velocity on muscle balance (H/Q peak torque ratio) between hamstrings and quadriceps as well as isokinetic knee muscle strength asymmetry and gender differences in athletes. We also investigated angle specific ratio (ASR) with torque values assessed at 30° because the largest occurrence of knee injuries such as an ACL injury or hamstring injuries occurs at the end of the range of motion (12). Although there was no significant difference in terms of H/Q ratio, ASR and bilateral deficit for extensor muscles between the sexes in both angular velocities for the dominant and non-dominant legs, female players presented significantly higher bilateral deficit for flexor muscles in both angular velocities (p<0.05).

Renstrom et al. found that H/Q peak torque ratios tend to be higher in men than in women (22). In a systematic review, Hewett et al. found that the significantly greater H/Q peak torque ratios were observed in men than in women at increased angular velocity, whereas no differences in isokinetic H/Q peak torque ratio between the sexes were observed at lower angular velocities (16). Andrade Mdos et al. investigated difference in H/Q peak torque ratios calculated at angular velocities of ›

Table 5

The bilateral strength deficit for the dominant and non-dominant legs in male and female soccer players. *p<0.05, significant difference.

| VARIABLES | MALE | FEMALE | P* |
|---|---|---|---|
| Bilateral deficit for extensor muscles 60°/sec | 7.62±9.14 | 10.12±7.89 | 0.300 |
| | 7.0 (-7.0-28.0) | 7.5 (0.0-29.0) | |
| Bilateral deficit for extensor muscles 180°/sec | 12.35±18.99 | 10.50±8.59 | 0.564 |
| | 12.0 (-22.0-86.0) | 7.5 (0.0-32.0) | |
| Bilateral deficit for flexor muscles 60°/sec | 4.35±7.56 | 11.65±9.83 | 0.001 |
| | 4.0 (-11.0-26.0) | 9.0 (0.0-37.0) | |
| Bilateral deficit for flexor muscles 180°/sec | 2.85±19.56 | 7.96±7.02 | 0.018 |
| | 3.5 (-17.0-81.0) | 6.0 (0.0-24.0) | |

60°/sec and 180°/sec between men and women who participate in judo, handball or soccer to determine if there are differences due to the influences of gender, sports modality, and test velocity. They found that female soccer players produced lower H/Q peak torque ratios at 60°/sec than males whereas there were no significant differences between the sexes at 180°/sec (1). Contrary to the above studies, Zebis et al. found that there was no difference in the H/Q strength ratio during a maximal voluntary contraction between male and female soccer players (25). Consistent with the study by Zebis et al., there was no significant difference in terms of H/Q ratio between the sexes in our study. Hewett et al. suggested that imbalances in muscle strength, changes in neuromuscular control during maturation, and biomechanical factors like increased anterior shear on the tibia, valgus angulation, valgus torque, and tibial torsion may collectively increase the risk of ACL injury in female athletes, particularly at high angular velocities (16). Andrade Mdos et al. proposed that gender, sport modality and angular velocity influence the isokinetic strength profiles and, consequently, muscular balance at the knee (1). While Hewett et al. included untrained participants, college athletes, and injured participants in their study, Andrade Mdos et al. selected professional athletes just like us. We think that the physical differences of the participants may have revealed this results.

Angle-specific functional strength ratio can be calculated throughout the range of motion, but measurements in extended positions of the knee joint may be optimal for hamstring strain injury (13). Eustace et al. found that professional football players were able to maintain eccentric knee flexor strength at various angular velocities, but concentric knee extensor strength decreased with increasing angular velocity and knee extension angles (12). Huang et al. also found greater quadriceps torque deficits for lower knee flexion angles, whereas there was an opposite trend for hamstring torque, i.e. greater deficits at greater knee flexion angles (17). Eitzen et al. found that angle-specific quadriceps torque showed greater power deficits at knee flexion less than 40° compared to higher knee flexion angles (11). Baumgart et al. found that the angle-specific torques and HQ ratios were different between the operative and non-operative legs and velocities in patients after ACL reconstruction. They also found greater quadriceps defects in patients with ACL deficiency at knee flexion angles between 0 and 40° at 60°/s (4). Tengman et al. found that there was no difference for H/Q ratios between three groups (33 treated with ACL-reconstruction (ACL-R), 37 treated only with physiotherapy (ACL-PT), and 33 controls) but maximal concentric hamstring torque occurred at a lower angle for the injured leg in the ACL-R group compared to the control group (24). Çınar-Medeni et al. found no difference in limb and knee joint angle interaction for concentric and eccentric flexor and extensor torques between the involved and non-involved extremities in patients after ACL reconstruction but they observed higher torques for eccentric contractions compared to concentric contractions (6). Evangelidis et al. found no difference in the angle-specific functional H/Q ratio between male soccer players and recreationally active men at any velocity with the exception of the knee flexors concentric torque at 400°/sec (the higher concentric hamstrings torque exhibited by the football player) (13). Considering the above studies, we evaluated the angle-specific ratio (ASR) only at 30° and found no significant difference between genders in terms of ASR in our study. Evangelidis et al. suggested that the high rate of hamstring injuries seen in football may be because of another risk factors and/or just regular exposure to a high-risk activity (13). We also think that the lack of difference between genders in terms of ASR may be due to other affecting variables such as genetic factors, muscle imbalance, inadequate warm-up, poor flexibility, previous injuries, training errors, fatigue and overuse, poor environmental conditions, lack of recovery, age and fitness level.

In addition to the H/Q ratio, bilateral muscle asymmetry has also been recognized as a risk factor for lower extremity injuries and may also affect sports performance. Over time, the muscle loading patterns experienced in football may cause bilateral asymmetrical increase in the quadriceps muscle in the dominant kick leg due to superior use of the dominant leg. An athlete with asymmetrical strength may experience greater load on the weaker leg and be unable to support the impact, resulting in injury. Asymmetries in the highest isokinetic knee torque at 60°/sec were observed among football players. It has been shown that the incidence of ligament and muscle injury is up to 45% in those with asymmetry, compared to only 20% in individuals without lower extremity asymmetry. Therefore, analysis of bilateral strength asymmetry was considered important to control and reduce the risk of injury (8,10). It has been suggested that the injury rate increases when there is a 15% or greater difference in knee flexor or hip extensor strength in the dominant and non-dominant leg. In previous studies investigating the difference in strength between the legs in team sports, contradictory results were obtained such as the dominant leg being stronger or the non-dominant being leg stronger, or being no difference between the legs (15). We found significantly higher bilateral deficit for flexor muscles in female players for both angular velocities in our study. This may be related to differences in strength development between the legs depending on the athlete's position and style of play.

There are some limitations in our study such as the lack of eccentric torque evaluation, the absence of ASR values at angles other than 30º, high angular velocity evaluation (i.e. 240º/sec and 300º/sec). Further studies with knee muscles eccentric evaluation and ASR values at different angles are needed.

## Conclusion

Functional movements involving many activities in an open kinetic chain, such as football, require good dynamic knee joint stability. It can be assumed that the quadriceps strength improves more than the hamstring muscles in the soccer game and causes an imbalance that may predispose to injury. Given the critical role of the ACL in knee stability, it is critical to improve sufficient strength near full knee extension. Although this can be achieved with a higher H/Q peak torque ratio, the changes in speed should not be overlooked because the maximum hamstring and quadriceps torques used in calculating the H/Q ratio are angle-independent. Angle-specific strength assessments across a range of angular velocities may present a better method for identifying strength deficits and imbalances specific to injury mechanisms, as current practices of isokinetic strength assessments may not be entirely appropriate for determining injury risk. It can also provide additional information on injury prevention strategies (1). Bilateral muscle asymmetry may also be a risk factor for lower extremity injuries. Daneshjoo et al found that peak torques in the non-dominant leg were higher than the dominant leg at all angular velocities, but no significant difference emerged. Moreover, gender-related factors contain anatomy, hormonal profile, ligament laxity, and the effect of menstrual cycles on knee strength. Laxity of ligaments around the knee joint in women can affect knee strength (8). The results of the study can be summarized as follows: 1) H/Q ratio is depend on angular velocity in isokinetic strength testing, 2) Although females exhibit lower H/Q ratios than males, H/Q ratio not significantly differed depending on gender, 3) There is a high trend towards asymmetry in female athletes compared to male athletes and 4) There is a moderate correlation between H/Q ratio and ASR, which means there are other influencing variables such as differences in muscle activation patterns at different joint angles, biomechanical factors, muscle length-tension relationship (because muscles generate the most force within a specific range of lengths), individual variability (such as differences in muscle fiber type distribution, which can affect the H/Q ratio and torque at specific joint angles), fatigue and training status. Whether testing at a specific range of angles will be performed in the future depends on the specific goals of the assessment. If the aim is to evaluate muscle imbalances or target rehabilitation exercises, testing at specific joint angles related to the individual's sports or injury history may be valuable. It may involve tests at various joint angles to provide a more complete picture of muscle strength and imbalances. This study implies that H/Q ratio is different at various knee flexion angles and future studies should investigate if these approaches are better to identify risc factors.

**Conflict of Interest**
*The authors have no conflict of interest.*

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