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Evaluation of Postural Balance and Hamstring/Quadriceps Peak Torque Ratios According to Leg Dominancy in Turkish Female Volleyball Players

Türk Kadın Voleybolcularda Baskın ve Baskın Olmayan Bacaklarda Postüral Denge ve Hamstring/Quadriceps Zirve Tork Oranlarının Değerlendirilmesi

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ABSTRACT

Objective: The aim of the study is to determine hamstring/quadriceps (H/Q) strength ratio, peak torque (PT), and postural balance (PB) in dominant (D) and non-dominant (ND) legs in Turkish female volleyball players.

Methods: This cross-sectional study included 63 Turkish Women's Volleyball 1st league players with a mean age of 21.9±4.4 yr, mean height of 182.0±5.9 cm and mean body weight of 66.5±8.3 kg. Dynamic balance measurements were performed for 20 seconds and three repetitions for each leg. Overall stability index (OSI), anterior/posterior stability index (APSI) and medial/lateral stability index (MLSI) data were collected. Afterwards, hamstrings and quadriceps PT was measured with an isokinetic dynamomoter for concentric/concentric (con/con) contractions at both speeds of 60˚/s and 180˚/s. Wilcoxon Test was used for statistical analysis.

Results: Statistically significant difference was found for quadriceps muscles' PT between dominant or non-dominant legs at 60˚/s. H/Q ratios were found lower in the dominant leg, with statistical significance at 60˚/s. No statistically significant difference was found for OSI, APSI and MLSI between dominant and non-dominant legs.

Discussion: H/Q ratios increase with higher angular velocity. Also, there are statistically significant differences in PT and H/Q ratio at 60˚/s between dominant and non-dominant legs. These findings may indicate that the non-injured leg can not be used as a reference for the injured leg in case of injury in female volleyball players, regardless of which leg is involved.

Keywords: Volleyball, isokinetic strength, H/Q ratio, postural balance

ÖZ

Amaç: Çalışmanın amacı Türk kadın voleybolcularda dominant (D) ve non-dominant (ND) bacaklarda H/Q (hamstring/quadriceps) oranı, zirve tork (PT) değerleri ve postüral dengenin değerlendirilmesidir.

Yöntem: Bu kesitsel çalışmaya ortalama yaşları 21.9±4.4 yıl, boyları 182.0±5.9 cm ve vücut ağırlıkları 66.5±8.3 kg olan 63 sağlıklı Türkiye Kadınlar Voleybol 1. Ligi oyuncusu dahil edildi. Denge ölçümleri her iki bacağa 20 saniye ve üçer tekrar şeklinde uygulandı. Denge ölçümlerinde toplam denge kaybı (OSİ), anterior-posterior denge kaybı (APSI) ve medial-lateral denge kaybı (MLSI) verileri toplandı. Sonrasında izokinetik dinamometre ile

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hamstring ve quadriseps PT ve H/Q oranları 60˚/s ve 180˚/s hızlarda ölçüldü. İstatistiksel analizde Wilcoxon Testi kullanıldı.

Sonuçlar: Hamstring veya quadriceps kaslarının PT değerlerinde dominant ve non-dominant bacaklar arasında 60˚/s hızda istatistiksel olarak anlamlı fark bulundu. H/Q oranları D bacakta daha düşüktü ve 60˚/s hızda istatistiksel olarak anlamlı fark vardı. D ve ND bacaklar arasında OSİ, APSI ve MLSI'de anlamlı bir fark saptanmadı.

Tartışma: Açısal hız arttıkça H/Q oranları artmaktadır. D ve ND bacaklar arasında PT, H/Q oranında 60˚/s hızda istatistiksel olarak anlamlı bir fark bulundu. Bu bulgular, kadın voleybolcularda yaralanma durumunda, hangi bacak olduğuna bakılmaksızın, yaralanmamış bacağın diğer bacak için kuvvet açısından referans olarak kullanılamayacağını gösterebilir.

Anahtar sözcükler: Voleybol, izokinetik kuvvet, H/Q oranı, postüral denge

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INTRODUCTION

Volleyball is a sport that is played in a relatively small area. Volleyball players perform numerous jumps and spikes during matches and trainings that require adequate control of shoulder, lower back and leg muscles, and they use powerful and explosive force during these movements. When performing these tasks, they jump and land vertically. During these tasks, as balance is acutely disturbed, the players must react quickly in order to maintain balance. Postural control is very important for the players during volleyball actions.

Injuries are often seen in volleyball. Muscle strength imbalance is one of the main causes of sports injuries (1). Muscular function is very important in athletes for injury prevention and monitoring the rehabilitation. Hamstring and quadriceps muscles have key roles in many of physical activities such as running and hopping.

The difference of muscle strength between dominant (D) and non-dominant (ND) legs, agonist/antagonist muscle strength ratio and lower limb stability are all important for preventing injuries, especially in the knee joint. The ratio of maximal isokinetic hamstring muscle strength to maximal isokinetic quadriceps muscle strength (H/Q ratio), is a commonly used parameter to describe muscle strength properties around the knee joint (2). Concentric hamstring/quadriceps (Hcon/Qcon) strength ratio is the most commonly reported ratio for the knee joint. While Hcon/Qcon ratio is the conventional ratio, the Hecc/Qcon is considered as the functional ratio.

Sufficient quadriceps and hamstring strength is required for sports performance. These two muscles are functional antagonists. Both muscle groups should have adequate strength for running, jumping, hopping, landing and other sporting activities (1). Muscle strength can be appropriately measured with an isokinetic dynamometer (3). The isokinetic strength test can be performed in order to determine concentric or eccentric muscle strength at constant angular velocities.

Vertical jumping is one of the basic movements in volleyball. Therefore, jumping higher is one of the training aims. Strength training is used to achieve this goal (4). There are two basic functions of the extensor mechanism that underline jumping skills: concentric contraction during the acceleration phase of jumping, and eccentric contraction during the landing phase. Due to such loading on the extensor mechanism, there may be an imbalance between the extensor and flexor muscles, which causes overloading of the tendon structures around the knee joint (5).

In many movements in volleyball, the quality of postural control is also essential. Serving, passing reception, or defensive actions are influenced by the athlete’s ability of dynamic balance control. Volleyball players must adapt their positions very quickly to react to the positions in the game (6). In this respect, it is important to determine the balance ability of volleyball players and to investigate the factors affecting it (7). The single leg balance test has been widely used for stabilometric assessment in similar studies.

Following injury, the healthy leg is generally accepted as a reference for the assessment of the injured leg, but the relationship of strength, H/Q ratio and balance between D and ND legs in volleyball players is not known . The objective of this study is to determine 1) Hamstring and quadriceps muscles' peak torque scores for D and ND legs, 2) conventional Hcon/Qcon muscle strength ratios, 3) balance ability in D and ND legs for Turkish professional female volleyball players. The aim of the study is thus to determine H/Q strength ratio, PT and PB in D and ND legs in female Turkish volleyball players.

MATERIALS and METHODS

The study has been approved by the local Research Ethics Committee with the protocol number of 14-892-17. Sixty-three healthy Women Volleyball First League players who train for 15 hours weekly, and who have a mean age of 21.9 years (between 17-25), mean height of 182.0 cm (between 170-192) and mean body weight of 66.5 kg (between 50-92) were included in the study. Each participant was informed about the study and written consent was taken through an Informed Consent Form. The procedures were in accordance with institutional and national ethical standards for human rights and the Helsinki Declaration was respected. All participants had performed the isokinetic strength test at least once and none of the participants had any history of knee or ankle surgery. The leg that the player uses for hitting the ball was considered as the D leg.

One of the author tested the participants, while at least another author was observing. The initial test was balance measurement and it consisted of three trials (each lasting 20 s), and was performed for both legs. Between trials, athletes were allowed to rest for 10 seconds. Balance measurements were performed with a balance device (Biodex Balance Systems SD, Biodex Medical Systems, Shirley NY, 11967, USA). Balance measurements include anterior/ posterior stability index (APSI), medial/lateral stability index (MLSI), and overall stability index (OSI) scores. These indices indicate standard deviations from the center of the platform. The OSI score is calculated by combining APSI and MLSI scores. All three indices were automatically calibrated by a computer software. A high index score indicates poor balance. The OSI balance score is thought to be the best indicator of the patient's ability to hold the platform in place (8). The foot position of the athletes remained constant throughout the measurement.

Following balance measurements, the athletes performed warm up with a cycling ergometer (Monark, Sweden) at 50 W for 5 minutes. Thigh strength measurements were performed with the Biodex Isokinetic Systems Pro device. After warm-up, peak torque (PT) of hamstring (H) and quadriceps (Q) muscles, and conventional H/Q ratios were measured by an isokinetic dynamometer at 60˚/s (five repetitions) and 180˚/s (10 repetitions) angular velocities. Between measurements, athletes were allowed to rest for 3 min. For isokinetic measurements of both legs, the subjects sat on the dynamometer's adjusted seat, and their low back, thigh and upper extremities were fixed. Measurements were performed on the same day for both D and ND legs.

Non-parametric Wilcoxon test was used as the data were not normally distributed. All variables are reported as mean ± standard deviations.

RESULTS

Mean values of H PT and Q PT at 60˚/s in the D leg were 86.7 ± 17.0 Nm and 179.3 ± 34.0 Nm respectively, and in the non-dominant leg they were 89.3 ± 22.0 Nm and 172.8 ± 33.0 Nm, respectively. For the D leg, at 180˚/s, H PT and Q PT mean values were 64.0 ± 13.0 Nm and 121.5 ± 22.0 Nm, respectively, and for the ND leg these mean values were 65.0 ± 15.0 Nm and 118.6 ±

18.0 Nm, respectively (Table 1) (Fig. 1-2). For D and ND legs, H/Q ratios at 60˚/s were 49.0 ± 9.0 and 51.7 ± 10.0 %, respectively, and at 180˚/s, they were 52.9 ± 7.0 and 54.8 ± 9.0 %, respectively (Table 1, Figure 3).

Table 1. Hamstring and quadriceps muscles' PT (Nm) and H/Q ratio evaluations at different angular velocities (means ± SD)

Angular velocity		D leg	ND leg	p
60˚/s	H PT	86.7 ± 17.0	89.3 ± 22.0	.220
	Q PT	179.3 ± 34.0	172.8 ± 33.0	.001*
	H/Q	49.0 ± 9.0	51.7 ± 10.0	.013*
180˚/s	H PT	64.0 ± 13.0	65.0 ± 15.0	.515
	Q PT	121.5 ± 22.0	118.6 ± 18.0	.063
	H/Q	52.9 ± 7.0	54.8 ± 9.0	.180

*: p<0.05; H: hamstring, Q: quadriceps, PT: peak torque (Nm), D: dominant, ND: non-dominant, H/Q: hamstring to quadriceps PT ratio (%)

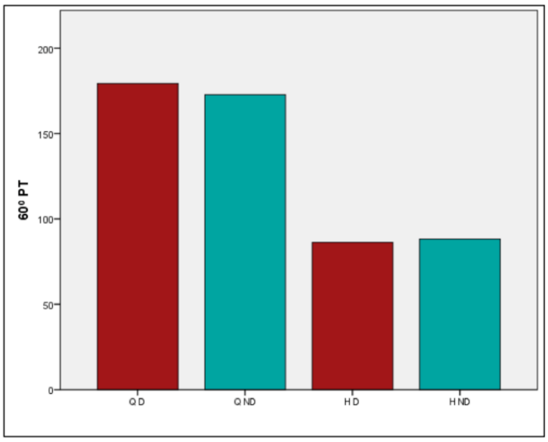

Figure 1. Quadriceps and hamstring muscles' mean peak torque values in dominant (D) and non-dominant (ND) legs at 60°/s

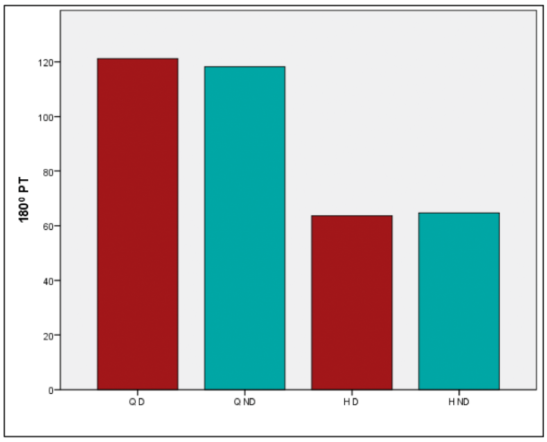

Figure 2. Quadriceps and hamstring muscles' mean Peak Torque values in both D and ND legs at the speed of 180°/s

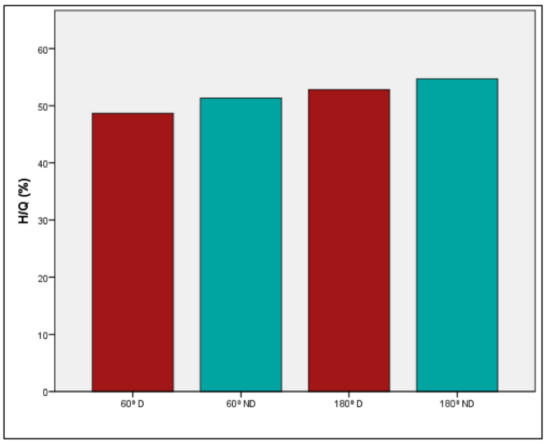

Figure 3. Mean Hamstring (H)/Quadriceps (Q) muscles' strength ratios at 60/s and 180/s

Q PT values were significantly higher in the D leg than the ND leg at 60˚/s angular velocity ($p<0.05$), whereas the difference of H PT values was not significant ($p>0.05$) at the same angular velocity, although peak torques were higher in ND leg than the D leg. PT levels decreased as the speed increased. H/Q ratios were lower in the D leg than the ND, and the ratio increased as angular velocity increased. A statistically significant difference ($p<0.05$) was found between the two legs in terms of H/Q ratio at 60˚/s angular velocity. D leg OSI was 1.82 ± 0.70, APSI was 1.18 ± 0.50, and MLSI was 1.21 ± 0.50; and for the ND leg OSI was 1.79 ± 0.50, APSI was 1.20 ± 0.40, and MLSI was found to be 1.17 ± 0.40, but there was no statistically significant difference between D and ND legs in terms of loss of balance (Table 2).

Table 2. Single leg balance scores (means ± SD)

	D leg	ND leg	p
OSI	1.82 ± 0.70	1.79 ± 0.50	.870
APSI	1.18 ± 0.50	1.20 ± 0.40	.810
MLSI	1.21 ± 0.50	1.17 ± 0.40	.462

OSI: overall stability index, APSI: anterior/posterior stability index, MLSI: medial/lateral stability index

DISCUSSION

The aim of this study is to determine H and Q muscles' PT, conventional Hcon/Qcon muscle strength ratio, balance ability in D and ND legs for professional female Turkish volleyball players.

H/Q ratio was lower in the female volleyball players when compared with American Football League players (0.68 ± 0.13 for the D side, 0.69 ± 0.14 for the ND side) (9), professional soccer (57.8 ± 8.4 for the D side, 57.7±7.4 for the ND side) at 60˚/s angular velocity (10). In Andrade et al.'s study, the H/Q ratio for judo, handball and soccer players was 57 ±14, 63 ± 12, 66 ± 12 for males, and 53 ± 10, 56 ± 6, 54 ± 11 for females, respectively (11).

There was statistically significant difference for the H/Q ratio between the D and ND legs in female volleyball players at 60˚/s angular velocity. The H/Q ratio is one of the most widely used parameters in this context (12). If the quadriceps generates considerably larger forces compared with the hamstring, extreme anterior translation during dynamic activities can occur, and as a result, the anterior cruciate ligament (ACL) will be subject to high shearing/cutting forces. The hamstring stabilizes the knee together with the ACL, preventing anterior translation of the tibia. ACL can be injured if the hamstring is comparingly too weak (12). The generally accepted opinion is as such, but the relationship between the mechanically measured muscle strength and the injury that can occur during match or training can be naturally disputable.

The ideal H/Q strength ratio varies among research. In healthy individuals, the typical concentric H/Q ratio varies between 0.5 and 0.8, depending on the selected speed and angle during the test (13). It has been suggested that H/Q power ratios and bilateral leg strength differences are sports specific (12). The H/Q ratios obtained in our study are within this range, but closer to the lower limits. Steindler developed the generalization that the absolute knee extensor strength must be higher than knee flexor strength at the rate of 3:2 (i.e Hcon/Qcon of 0.66) (14). Values ranging from 0.43 to 0.90 for this ratio have been reported, as this depends on angular velocity, test position and the investigated group (13,15).

There is no clear consensus for the H/Q ratio, although the generally accepted value is 0.6 (16,17). However, it can not be said that this view is completely true for different types of sports. Bennell and colleagues found that the H/Q ratios of Australian footballers were 0.69-0.73 and 0.59-0.73 at 60˚/s and 180˚/s, respectively (18). Hadzic et al. found Hcon/Qcon ratio as 0.58 and 0.61 at speed of 60˚/s for right and left legs, respectively, in their study covering 1st and 2nd league level international volleyball players (19). In another study by Magalhaes et al. it was shown that the H/Q ratio at the speed of 90˚/s was 57.4 among soccer players, and 50.4 among volleyball players. Magalhaes' study also displayed a significant difference for the H/Q ratio at a speed of 90˚/s between soccer and volleyball players (20).

In our study, H/Q ratios were found to be 49.9 and 51.7 for the D leg and 52.9 and 54.8 for the ND leg at speeds of 60˚/s and 180˚/s, respectively. The highest and lowest H/Q values at 60˚/s for the D leg were 104.8 and 35.2; and for the ND leg they were 104.0 and 38.7. The highest and lowest H/Q ratios at 180˚/s for the D leg were 75.4 and 39.8; and for ND leg they were 89.2 and 39.6. H/Q ratios were not similar with the results of Hadzic et al.'s (20); while our results were much more similar with the results of Magalhaes et al.'s study (19). Hadzic et al. have found H strength to be higher in volleyball players at international level, which may have caused high H/Q ratio. In our study, as in the other study (21), the H/Q ratio was found to be higher as speed increases.

Different muscle strength profiles are seen among various sports disciplines. Magalhaes et al. found that sport types effect the isokinetic concentric H/Q ratio (20). In our study, the H/Q ratio of the ND leg was found to be higher as it was in the study of Holcomp et al (22). No statistically significant difference was found for the H/Q ratio between the D and ND legs in Daneshjoo and his colleagues' study in young footballer players (23), and also in Xaverova and his colleagues' study in women volleyball players (24).

In another study, the amount of co-activation in agonist and antagonist muscles were found related to the angular velocity and training type (25). This suggests that sport-specific muscle balance is necessary (16). Nosse evaluated strength relationship between knee flexor and extensor muscle groups, and found that there was no constant strength relation that can be applied for each individual; and he suggested that this is contrary to the generally accepted opinion according to which the knee flexor muscle group must constitute at least 60% of the force generated by the ipsilateral knee extensor muscle group (15). Athletes with a concentric H/Q ratio closer to 1.0 were found to possess lower hamstring strain risk (17). In addition, it has been suggested that as the concentric H/Q ratio of the athlete with ACL injury approaches 1.0, the risk of anterior-lateral subluxation of the tibia reduces (26). Generally, anterior tibial translation is thought to be related with the H/Q ratio (27). H/Q ratios that were found in our study were close to 0.5. If we assume that the H/Q ratio should be at least 0.6 as generally accepted, it may mean that we can expect high incidence of ACL injuries in volleyball players.

When we take a look at our study and other relevant studies, various sports disciplines may have their own different reference indices, so injury risk can be assessed adequately. In other words, sport-specific H/Q ratios can be created and these values can be used as reference in rehabilitation. Also, since there is widespread difference in H/Q ratio among individuals, it may not be appropriate to determine such a certain rate as a goal of successful rehabilitation (28). The result of our study such that there is significant difference in the strength and H/Q ratio for the D and ND legs at 60°/s angular velocity; so both les can not be used as reference for each other during rehabilitation in female volleyball players at 60°/s angular velocity.

Some studies have shown the relationship between ankle injuries with balance of the athlete (29,30). McGuine et al. showed that amount of swinging during single leg stance is correlated with ankle sprain in basketball players. Subjects with a high postural sway had about seven times more ankle sprains than subjects with a low postural sway (29). Investigating postural balance in sports may contribute to the development of postural strategies in sports (6).

In our study, we found better balance scores in OSI and MLSI in the ND leg, comparing with the D; but these results were statistically insignificant. One of the reasons underlying these results can be that the non-dominant leg has predominantly postural function in everyday life (31). It is observed that loss of APSI was less in the D leg.

The lack of a significant difference on postural balance between the D and ND legs can also be attributed to that volleyball players usually land on both legs and using them equally during landing. In Alonso et al.'s study (32), which included sedentary individuals and in Hoffman et al.'s study (32,33) which included young healthy individuals, there were no significant differences of balance between the D and ND legs, as in our study. Limitation of the study is that H/Q measurements were not performed as eccentric-concentric.

CONCLUSION

In our study, there was no significant difference between the D and ND legs in terms of balance in female volleyballs, and that the other leg can be taken as a reference in case of injury regardless of which leg is injured. There is significant differences in the strength and H/Q ratio for the D and ND legs at 60°/s angular velocity; so both leg can not be used as reference for each other during rehabilitation in female volleyball players at 60°/s angular velocity. The results obtained in our study may be used as a reference by clinicians and coaches.

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