ORIGINAL ARTICLE

Comparison of isokinetic leg peak torque, hamstring/quadriceps ratio and strength asymmetry of male volleyball players with similar age and different years of training

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ABSTRACT

Background: This study was conducted to compare isokinetic strength, hamstring/quadriceps ratios and dominant/non-dominant leg strength asymmetries of athletes at similar competition level with different years of training.

Aim: The aim of this study is to determine and compare isokinetic peak torque, H / Q ratios and bilateral force asymmetry in volleyball players.

Methods: The first group of volunteer participants consist of 10 healthy athletes with average of; 17.48±1.43 years old and 2.7±1.4 years of training. The second group of volunteer participants consist of 10 healthy athletes with average of; 17.40±1.53 years old and 5.7±0.9 years of training. The isokinetic muscle function of the knee was measured using the Cybex Norm 6000. Measurements were collected at angle speeds of 60 o/s and 180 o/s, for 6 and 15- repetitions respectively.

Results: The results of the present study show that, there is a statistically significant difference in the extension movement of athletes performed at 180o/s on both legs (peak torque) which is dominated by the quadriceps muscles ($p< 0.05$). However; H/Q ratios in both angular speeds do not reveal a statistically significant difference ($p>0.05$). Also, there is no statistically significant difference ($p>0.05$) when the right and left leg force asymmetry.

Conclusion: The training routines applied by volleyball teams do not have any effect on the isokinetic leg strength of the athletes playing in the junior teams. It is suggested that including specific strength exercises that will improve isokinetic strength in volleyball training programs for preventing injury risks in the future.

Keywords: Leg peak tork, volleyball, H/Q ratio, leg strength, isokinetic strength

INTRODUCTION

Volleyball is a sport in which (commonly) explosive power, velocity and agility distinguishes. It involves anaerobic efforts such as spike and block jumps, and phosphagen energy system is dominant in it[1,2]. In a volleyball match, the players are expected to switch swiftly, do technical movements with the ball, and perform offensive and block movements over the net. Besides, they are required to be able to absorb the forces that will occur during the intense vertical jump and landing, which are the requirements of spike and block, and they are also expected to repeat these in a trice[3]. In volleyball, which is one of the indoor hall sports involving jumping and running, the requisition for the motor skills of the hamstrings and quadriceps increases[4] as the athletes need stronger lower extremity extensor and flexor muscles to compensate for the frequent shift between acceleration and deceleration because of a relatively smaller playing field[5].

The hamstrings (flexion) and quadriceps femoris (extension) muscles are key effectors during high performance activities such as branch-specific running and jumping[6]. The hamstrings-quadriceps peak torque ratio (H/Q ratio) is one of the most widely used ratio of determining the performance of the athletes and monitoring the increase in the performance[5].

It is of capital importance to maintain the proper strength ratio between the hamstring and quadriceps in the lower extremity and to maintain symmetrical strength between the right and left sides[7]. For healthy athletes, a typical isokinetic concentric H/Q ranges from 0.50 to 0.80 based on angular velocity and it shows the muscle balance between the hamstrings and quadriceps[8,9].

This strength ratio of agonist to antagonist knee muscles is used to analyse the functional ability between the hamstrings and quadriceps, knee joint stability, and muscle balance during movements regarding to velocity[5,11]. Hamstring muscles stabilize the knee joint[12] by means of the anterior cruciate ligament[13] during the circular movements as a result of the rapid direction changes in volleyball. As the quadriceps produce considerably greater strength compared to the hamstrings, extreme forward transfer may occur during dynamical activities. Athletes may get injured during a rapid knee extension if the hamstrings cannot to produce efficient eccentric counter-motion in order to slow the motion[14]. The torque ratio of agonist to antagonist knee muscle is related to the requirement the sport, training adaptations and the level of the competition[5]. Accordingly, the H:Q ratios for athletes with high training age is expected to be at a rate that will reveal the eccentric and concentric contraction that can meet the requirements of the sport and also prevent the knee joint injury.

Various methods are used for designation of the dominant and non-dominant leg. While some researchers consider the front leg before the spike jump as the dominant leg in volleyball players[15], some other researchers use the ball-kick test[16,17]. In studies which embrace isokinetic tests, in order to determine the dominant leg, the leg with the highest peak torque force is considered to be dominant by considering the peak torque values[18,19]. Isokinetic-dynamometry is a safe and reliable method for estimating the maximum muscle strength[20,21]. It is stated that, besides concentric activation, isokinetic diagnostics which enables the identification of eccentric muscle abilities that are difficult to observe through traditional resistance measurement protocols such as free weights [22], may be a valuable predictor of lower extremity performance such as jumping [23].

The literature review on the issue shows that all of the researches carried out until today are studies on adult professional volleyball players [5,19,24], female athletes [15,25,26] or studies which compare volleyball players [4,5,27,28] with other branch athletes.

As far as it is known, there are no researches carried out on young athletes. Besides, there are no studies on athletes with similar age groups but different training years. From this point orth, this study was conducted to compare isokinetic strength, H/Q ratios and dominant/non-dominant leg strength asymmetries of athletes at similar competition level with different years of training.

Athletes with more years of training were expected to have higher peak torque value, similar H/Q ratio and lower bilateral asymmetry.

MATERIAL & METHODS

The first group of volunteer participants consist of 10 healthy athletes with average of; 17.48±1.43 years old, 184.38 ± 4.9 cm tall; 75.53±4,94 kg weigh; 9.68±1.08% body-fat per cent; and 2.7±1.4 years of training. The second group of volunteer participants consist of 10 healthy athletes with average of; 17.40±1.53 years old, 186.32±4.37 cm tall; 78.77±3.96 kg weigh; 9.72±1.21% body-fat per cent; and 5.7 ± 0.9 years of training. Among all participants, athletes who are below the average years of training (4, 2) composed the first group; athletes who are above the average years of training (4, 2) composed the second group. Ethics committee report was received from Kırşehir Ahi Evran University Ethics Committee before the study started (2020/5). All volunteers were verbally informed before they were included in the study, and their written consent to participate in the study was obtained.

All of the athletes are athletes with the same level of competition competing at the youth team level, having a training frequency of 5 days a week, holding one match a week in a season of 8 months and who have no injuries before and during the test.

Body-fat percentages of the participants were obtained via Tanita Bc 601 Innerscan Body Analyser and isokinetic leg torque data was obtained via Cybex Norm 6000 dynamometer device. The research was carried out at two different angular velocity. Angular velocities of $60^{o/s}$ and $180^{o/s}$, which are prevalent in the literature, are preferred [15,17,19].

Participants were tested; for trial three times and were tested for real six times at $60^{o/s}$ angular velocities; for trial five times and were tested for real fifteen times at $180^{o/s}$ angular velocities. Based on the isokinetic leg torque forces carried out in the present study, the dominant legs of the athletes were designated [18,19].

Ten minutes pre-test warm up consist of 5 minutes period of pedalling at 60 rpm at Monark 827E upright exercise bike and 5 minutes stretching peculiar to the branch.

The measurements were taken with regard to the match calendar of the participants and were taken based on appointment on the days which they did not take part in a match. In order to establish a standard, the participants were ensured not to do sports activities on the test day and take the test between 14.00-16.00 p.m.

Shapiro-Wilk test was used to find out whether the groups showed normal distribution or not. The averages of the normally distributed data were compared with Independent Samples T Test. The averages the data which did not distribute normally were compared with Mann Withney U test. Variances were observed to be distributed equally carrying out Levene variance analysis. Change in the percentage data was acquired by using the formula below.

The percentage of the Difference: (New Value/Old Value - 1)*100

RESULTS

Table 1. Descriptive Characteristics of the Participants

Characteristics	G1(n=10) $\bar{x}$±sd	G2(n=10) $\bar{x}$±sd
Age (year)	17.48±1.43	17.40±1.53
Body Weight (kg)	81.99±6.55	81.49±7.50
Height (cm)	186.21±7.04	185.55±6.86
Body Fat Percentage (%)	11.16±0.86	10.51±1.21
Training Age (year)	2.7±1.4	5.7±0.9

G1= Participants with a training age of 2.7±1.4 years; G2= Participants with a training age of 5.7±0.9 years
All parameters are similar in both groups, except training ages.

Table 2. Comparision of the Leg Peak Torque Values of the Participants

Limb Torque	Angel of Motion	Groups	$\bar{x}$	p	% df
RIGHT LEG PEAK TORQUE (Nm)	$180^{o/s}$ EKS	G1 G2	138.0±28.4 167.9±31.3	0.038	22↑
	$180^{o/s}$ FLK	G1 G2	85.6±23.8 104.4±28.5	0.127	22↑
	$60^{o/s}$ EKS	G1 G2	218.1±49.3 225.5±45.5	0.731	3↑
	$60^{o/s}$ FLK	G1 G2	131.0±36.1 127.2±31.1	0.804	3↓
LEFT LEG PEAK TORQUE (Nm)	$180^{o/s}$ EKS	G1 G2	131.7±26.2 161.1±35.3	0.049	22↑
	$180^{o/s}$ FLK	G1 G2	90.1±25.7 102.2±29.5	0.341	22↑
	$60^{o/s}$ EKS	G1 G2	200.3±45.8 222.2±54.7	0.345	13↑
	$60^{o/s}$ FLK	G1 G2	125.3±36.4 138.8±69.9	0.450	11↑

EKS (Leg Extansion); FLK (Leg Flexion)

Comparison of the peak torque values of the participants was given in Table 2. The results of the present study show that, there is a statistically significant difference in the extension movement of athletes performed at 180o/s on both legs which is dominated by the quadriceps muscles ($p< 0.05$). As the years of the training for young athletes increase a meaningful increase is observed in quadriceps strength ratios. In addition, the difference in strength in both legs is observed to increase by 22%. Even though, there is not statistically significant difference can be obtained in the flexion movement performed at the same angular velocity ($p< 0.05$), the percentage development of the force difference is 22% as in the quadriceps muscles involved in the extension movement.

These training adaptations do not reveal any statistical difference in the extension movement ($p> 0.05$) and flexion movements ($p> 0.05$) for the right leg at $60^{o/s}$, respectively. In addition, there is a 3% improvement in extension movement, while there is a 3% decrease in flexion movement.

There is no statistical difference in extension movement ($p> 0.05$) and flexion movements ($p> 0.05$) for the left leg at $60^{o/s}$ respectively. Although there was no statistically significant difference (except the right leg extension movement), 13% improvement in extension movement and 11% improvement (difference) in flexion movement were acquired.

Table 3. Comparision of the Hamstring / Quadirceps Ratios of the Participants

Limb Ratios	Angular Velocity	Groups	x̄	p	% df
RIGHT LEG H:Q RATIOS (%)	$180^{o/s}$	G1 G2	0.62±0.13 0.61±0.08	0.921	1 ↓
	$60^{o/s}$	G1 G2	0.60±0.17 0.56±0.08	0.879	7 ↓
LEFT LEG H:Q RATES (%)	$180^{o/s}$	G1 G2	0.68±0.13 0.63±0.11	0.343	8 ↓
	$60^{o/s}$	G1 G2	0.62±0.12 0.62±0.22	0.307	0

The comparison of the H/Q ratios of the participants is given in Table 3. With regards to the data in the table, the H/Q ratios in both angular speeds do not reveal a statistically significant difference ($p>0.05$). However, there has been a deterioration in percentage values among the compared rates. For the right leg, there was a decrease of 1% and 7% in the ratio comparisons of 180°/s and 60o/s, respectively. For the left leg, there has been an 8% deterioration comparing the values obtained at only 180°/s angular velocity. On the other hand, the data of the group with the lower training years is found to be higher than the group with the higher training years (except left leg 60°/s ratio).

Angular Velocity	Angular Motion	Groups	x̄ (%)	p	% df
ASYMMETRY RATIO ($180^{o/s}$)	EKS	G1 G2	9.83±6.77 8.99±6.23	0.970	9↓
	FLK	G1 G2	12.40±5.70 9.60±7.97	0.378	23↓
ASYMMETRY RATIO ($60^{o/s}$)	EKS	G1 G2	8.97±6.71 10.73±7.03	0.574	20↑
	FLK	G1 G2	12.95±11.61 16.03±11.38	0.406	24↑

EKS (Leg Extansion); FLK (Leg Flexion)

There is no statistically significant difference ($p> 0.05$) when the right and left leg force asymmetry data in Table 4 were analysed. Nevertheless, strength asymmetry at speeds of 60o/s, which is the indicator of maximal strength, increases 20% for muscle and muscle groups involved in extension movement, and 24% for muscle and muscle groups involved in flexion movement. On the other hand, similarly, no statistically significant difference occurs at angular velocities of 180o/s. A decrease of 9% was obtained for the muscle and muscle groups involved in the extension movement, and 24% for the muscle and muscle groups involved in the flexion movement.

DISCUSSION

Peak Torque: In this part, data obtained in the present study will be discussed associating to a limited number of studies. The peak torque forces obtained in a studies performed at the same angular velocities in volleyball players of similar age and volleyball players in similar competition groups correspond with the data obtained from this study[3,29].

In a similar study, while no statistical difference was found between the relative peak torque values on similar age groups in different leagues, it was observed that the specific trainings performed apart from the routine trainings that the athletes worked out improved the peak torque strength values of the athletes[29].

In a study which compared different sports branches, volleyball players and football players showed similar hamstring peak torque strength, while volleyball players exhibited more quadriceps peak torque strength than footballers[10].

In the light of the information obtained, even though the years of training increased, the trainings performed in the volleyball branch did not provide any improvement in lower extremity peak torque values. The findings of the present study assert that if the male athletes who are interested in volleyball are not exposed to a training application that will improve the isokinetic leg strength values at any stage of their sports life – from beginner to professional – will have difficulty in meeting the requirements of the professional structure.

H/Q: Strength asymmetry of the lower extremity is the inequality of strength between both leg quadriceps (Q) and hamstrings (H) [7]. Although Hewett et al. [9] reported that the reference interval varied by 50-80% depending on the angular velocity used in the test, Ermiş et al.,[17] reported that 60% was considered normal.

As a result of the isokinetic power test performed at two different angular speeds, there is no statistical difference between the two legs H/Q ratios. On the other hand, it is observed that in the group with higher years of training, 60% H/Q ratio, which is accepted as the injury limit, tends to the lower values.

While different H/Q ratios are reported at similar angular velocities in older age male volleyball players[10]. Studies reveal that national athletes and younger athletes have high H:Q ratio[3].

Studies report that there is no statistical difference in H/Q ratios at low angular velocity ($60^{o/s}$), on the other hand, a statistical difference was found in H/Q ratios at high angular velocity (180 $^{o/s}$)[4]. There are also studies in which H/Q ratios show statistically significant difference in both angular speeds[29]. The data obtained at both angular speeds reveal that in the upper leagues where experienced athletes take place, the H/Q ratio falls below 60% and the difference in agonist-antagonist muscle strength increase.

It is thought that the H/Q ratios move towards values that will cause injury as the training adaptation of the athletes in this training and competition level takes place and accordingly increase the risk of injuries. Peculiar trainings should be included to the training routines of this age group so as to H/Q ratios would not lead to injuries. We think that if such training programs are still exercised in the future, there would be increase in the possibility of injury.

Asymmetry: As volleyball players have lesser specific unilateral leg movements compared to the other sports (basketball, handball and football), men's volleyball is defined to be not bilaterally asymmetric[21]. Block and spike jump which involve vertical jump peculiar to the branch is executed through both legs. When this is taken into account, it is emphasized that volleyball players should have more symmetrical strength[10]. The data of the present study supports this fact in the literature. Apart from the data obtained within this study, researchers have also cited that the asymmetry values of the athletes in different leagues were below 10% in both angular velocities having no statistical difference and there was no difference between the peak torque strength values of both legs, so exists any asymmetry[10].

When both the age and the years of training increase, routine technical and condition training in volleyball branch creates strength asymmetry at low angular velocities. This means that young athletes have the risk of injury in angular motions that require maximal effort. Young volleyball players move away from injury risk limit (15%) when they make movements at high angular speeds. This is supposed be caused by explosive movements that repeat themselves in short periods of time volleyball. While the percentage of strength asymmetry between right and left legs decreases at $180^{o/s}$ speed, the rate of asymmetry strength difference increases in percentage at $60^{o/s}$ speed. As the years of training increases, the difference between right and left leg strength increases in the movements that athletes perform at low angular velocities. These movement are mostly related to maximal strength and explosive force. These differences in strength are thought to affect performance as well as lead to injuries.

CONCLUSION

The training routines applied by volleyball teams do not have any effect on the isokinetic leg strength of the athletes playing in the junior teams. In addition to this, the data of the study points out that in groups with increasing training adaptations, asymmetry occurs between dominant and non-dominant leg forces, and strength imbalances show up especially for the hamstring group muscles that takes part in the flexion of movements to be performed at an angular speed of $60^{o/s}$ that require maximal force.

The crucial point to be considered is that while the training routines meet the requirements of the branch they should also improve the physical health status of the athletes. Today, volleyball exercises are considered not to contribute to the isokinetic strength development of volleyball players and to cause muscle strength asymmetry. It is a fact that volleyball players must increase their jump height for the movements they will make on the net and they are required to be able to absorb the forces that will occur during landing. Repetitive movements that require explosive force in volleyball can help develop strength for muscles, such as the quadriceps, one of the largest muscle groups in the body. However, this study reveals that the same growth percentages are not valid for the hamstring group muscles, which are antagonists of the quadriceps muscle. Similarly, it is known that the differences in strength or growth percentages of the agonist-antagonist muscle groups in the same joint will decrease the quality of the motor movement, and also cause injuries[5]. Therefore, it is suggested that including specific strength exercises that will improve isokinetic strength in volleyball training programs for preventing injury risks in the future.

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