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Evaluation of Lower Extremity and Core Strength in Young Female and Male Volleyball Players

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Abstract Volleyball is an anaerobic team sport that involves various complex movements and requires adequate body position sense. Therefore, volleyball players' most important physical characteristics are balance, agility, endurance, reaction speed, explosive strength, and quick strength. This study aimed to evaluate the relationship between core strength and functional performance of lower extremities in male and female volleyball players. A total of 19 (11 female, eight male) volleyball players aged 16-20 years (11 female, eight male) who were students of Ondokuz Mayıs University Yaşar Doğu Faculty of Sports Sciences participated in the study voluntarily. The inclusion criteria were determined as athletes with at least three years of active sports history and regular training. Height, weight, and Body Mass Index measurements were taken at the first visit. Then, shuttle test, plank test, push-up, single hop for distance (SH), triple hop for distance (TH), crossover triple hop for distance (CH), medial side triple hop for distance (MSTH), and medial rotation (90°) with hop for distance (MRH) and Y Balance Test were performed with randomized practice cards. When the push-up, sit-up, and plank tests were compared between men and women, a significant difference was found in the shuttle parameter ($p>0.05$). When the athletes' Single Leg Hop test parameters were evaluated, there was no significant difference, only in SH between the sides in men. At the same time, there was no significant difference only in medial rotation (90°) with hop in women ($p>0.05$). While there was a significant difference in triple hop for distance, crossover triple hop for distance, medial side triple hop for distance (MSTH) and medial rotation (90°) with hop between the parties in men, a statistically significant difference was found in single hop for distance, triple hop for distance, crossover triple hop for distance, medial side triple hop for distance parameters in women ($p<0.05$). When single-leg hop Tests LSIs were compared between male and female groups, no statistically significant difference was found in all parameters ($p>0.05$). When the findings of our study were examined, it was determined that although there was a significant difference in Single Leg Hop test parameters between dominant and non-dominant sides in the groups, the LSI values seen in male and female groups were between normal values, and there was no limb asymmetry. However, there was no difference between genders in LSIs, and similar results were found for men and women. In the core strength tests, while similar results were seen between genders in push-up and plank parameters, the significant difference in the shuttle test revealed that men had better core strength than women.

Key Words volleyball, lower extremity strength, core strength, single leg hop tests

1. Introduction

Volleyball is a team sport that includes various complex movements such as technical-tactical, skill, and physical performance capacity as well as anthropometric characteristics [1]. Therefore, volleyball players' most important physical characteristics are balance, agility, endurance, reaction speed, explosive strength, and quick strength [2].

In order to maximize these performance parameters required for volleyball players, it is necessary to increase muscle strength [3]. Muscle strength enables a particular muscle to produce the same amount of work in a shorter time or a larger amount of work at the same time. This is crucial for sprinting, jumping, and fast direction changes [4]. Core training is one of the many factors that help to increase muscle strength. The core refers to the area covering the abdomen, waist, hips, and pelvis, which is used to name the region consisting of 29 different muscles [5]–[7].

The core is also considered the center of gravity, and the most important aspect is that all movements start in this region [8]. Increasing the balance and strength of this

region, strengthening it healthily, contributes to athletes performing more efficiently in long-lasting struggles by using less energy, allowing them to get tired later and using less energy [9]. It is argued that lower and upper extremity (arm and leg) movements play a more effective role in sportive performance due to endurance and resistance training. At the same time, the athlete's physical structure combines with core training, resulting in a visible change in characteristics such as strength, speed, power, endurance, and flexibility [10]. Exercises that correct the lower and upper extremities have started to be developed using functional training patterns in recent years [11]. When we look at the functional training for the volleyball branch, it is seen that there are generally studies related to the lower extremities, and there are more vertical jumping exercises [12]. Jumping is a skill that includes a complex series of movements [13]. In addition, functional training tests can be applied during the match with upper extremity-related studies. There is a need to evaluate performance before, during, and after the season to prevent injury and to decide on a return to sport. However, the number of studies on using and evaluating upper extremity tests in functional training is quite tiny [14]. Therefore, our study, which aimed to evaluate male and female volleyball players' lower extremities and core strength, was hypothesized to have significant and insignificant results between genders.

2. Materials and Methods

A. Experimental Design

The measurements were performed in a total of 3 visits and all measurements were taken between 12:00-14:00. The athletes performed sit-ups, push-ups, planks, single hop for distance (SH), triple hop for distance (TH), crossover triple hop for distance (CH), medial side triple hop for distance (MSTH), and medial rotation (90°) with hop for distance (MRH) and Y Balance Test. Before starting the tests, the athletes were informed about the test protocols to be applied. Athletes were warned not to perform any exercise or physical activity during the study period. Before the tests, the athletes were given light training mainly to warm up the lower extremity muscles. At the first visit, Height, Weight, and body mass index (BMI) measurements were taken of the subjects. Then, the tests to be applied to the subjects were randomized with application cards. In the second and third visits, the subject was administered the tests selected from the application cards.

APPLICATION CARDS;

1) -Sit-up Test, Plank Test, SH, TH, CH
2) -Push-up Test, MSTH, MRH, Y balance Test

B. Participant

A total of 19 volleyball players (11 females, eight males) were students of Ondokuz Mayıs University Yaşar Doğu Sports Sciences Faculty, with mean age, Height, Weight, and BMI of 17.8, 1,72 cm, 61,63 kg, and 20,63 kg/m2, respectively, in the age range of 19-23 years, with at least three years of active sports history and regular training, participated in the study voluntarily.

C. Procedures

Height and Weight Measurement: The Height of the athletes was measured with a tape measure with bare feet, body upright, and head facing forward, while the athletes' body weight was measured with a digital scale with a precision of 0,1 kg [15]. In addition, the body mass indexes of the athletes were calculated. This calculation was performed by dividing the body weight measurement by the square of the height measurement [16]. Body Mass Index (BMI): Body mass index was applied after height and weight measurements and calculated using the formula. FORMULA: BMI = Weight (kg) / Height (m2).

D. Core Strength Tests

Push-up Tests: Push-up tests were applied to determine the athletes' upper body and muscular endurance strength. During the test, the athletes were asked to stand in a prone position, arms, and body straight, without bending their hands, and the distance between the two hands should be shoulder width apart while at the same time, they were asked to take a position on their toes. Immediately after the athletes took the correct position, the command "start" was given. The test was performed twice, and the best measurement was recorded in units after both push-up attempts [17]. Sit-ups Tests: To determine the strength and endurance level of the flexor muscles in the abdominal and hip region of the athletes, shuttle test was applied to the athletes. During the test, 19 athletes were asked to lie on their backs on the floor, and at the same time, their hands were joined behind their backs. They were told to stand with their knees bent 90° and the soles of their feet ultimately touching the ground. The athletes were asked to continue sit-ups until the last part they could endure. Two measurements were made, and the best number of sit-ups was recorded [17]. Plank Tests: The plank test was used to test the endurance and strength level of the flexor muscles in the trunk region. 19 athletes were first asked to lie face down on the floor, then to touch the palms of their hands completely adhered to the floor and to remain in a (90°) bent position with their arms parallel to the floor. At the same time, they were asked to keep their toe tips in contact with the floor and stand in that position without moving. They were then reminded to maintain a straight body position throughout the test. The test was terminated when the athletes lost their position and fell to the ground. The test was repeated twice, and the best death was recorded [17].

E. Lower Extremity Strength Tests

Single Hop for Distance (SH) for Single Leg Hop for Distance (SLHT): 15 cm wide and 6 m long strip was drawn. The athlete was asked to stand on one foot and jump to the farthest point. He/she could jump parallel to the ground at the designated lane line. It was measured from the beginning of the strip to the athlete's heel level. Athletes were given

two attempts, and the best jump was recorded in cm [18]. Triple Hop for Distance (TH): The athlete was asked to stand on one foot and jump two consecutive times to the farthest distance he/she could jump parallel to the ground at the level of the drawn tape. The distance between the starting line and the place where the athlete jumped was measured at the heel level. Athletes were given 2 attempts, and the best jump distance was recorded in cm [18]. Crossover Triple Hop for Distance (CH): The athlete was asked to stand on one foot and jump two times in succession to the farthest distance he/she could jump parallel to the ground at the level of the drawn strip. The first jump was made to jump in the opposite direction of the foot, which he uses more in daily life, that is, diagonally. And it was asked to continue the movement sideways to the fallen place. The distance between the starting line and the place where the athlete jumped was measured from the heel level. Athletes were given two rights; the best jump was recorded in cm [18]. Medial Side Triple Hop for Distance (MSTH): The athlete was placed on the floor with the inner side of one foot facing the prepared strip and was ensured to take the correct position. The athlete was asked to jump on one foot sideways two times without stopping. The distance between the back of the athlete's foot and the place where the athlete jumped from the starting line was measured. Athletes were given two rights; the best jump was recorded in cm [19]. Medial rotation (90°) with the hop for distance (MRH): The athlete was placed on the floor with the inside of his/her foot facing the prepared strip and was allowed to take the correct position. The athlete was asked to jump sideways but was reminded that he/she should rotate in the air and fall to the ground in the direction of the strip. The athlete was asked to rotate once and jump to the farthest distance he/she could jump in a single move. The distance between the starting line and the place where the athlete jumped was measured at the heel level. The athlete was given two attempts; the best attempt was recorded in cm [19].

F. Balance Tests

The Y Balance Test, which consists of three parts: anterior, posteromedial, and posterolateral, was used to measure the dynamic balance of the lower extremity. This test aims to predict problems in the lower extremities and test balance control [2]. The measurement was applied to the athletes' dominant and non-dominant (dominant and non-dominant) feet. The angle between the three zones (anterior, posteromedial and posterolateral) on the measuring equipment was 120 degrees. The athletes were asked to stand in balance with their hands in the waist region and their feet fixed at the center point on the place to be measured [20]. Then, while maintaining a fixed stance with the foot in the center, the athletes were warned that the foot in the air should not touch the ground in any way while heading towards the anterior, posteromedial, and posterolateral directions with the other foot, respectively, and the athletes were warned that the foot in the air should not touch the ground in any way while heading towards these angles [21]. The test was repeated up to 3 times in all directions, and the best measurements were recorded in cm. The normalization formula was then used to evaluate the measurement results: ((Anterior+Posteromedial+Posterolateral)/3*Limb Length)*100.

G. Statistical Analysis

SPSS 21 package program was used in the statistical analysis of the study. The results are presented as mean and standard deviation. Shapiro-Wilk test was used for the normality test, and Levene's test was used for homogeneity assumptions. The athletes' dominant and non-dominant side comparisons were made with a Paired Samples t-test, and an Independent Sample t-test was used for intergroup comparisons. The results were considered significant at $p<0.05$, 95% confidence interval.

3. Result and Discussions

When the push-up, sit-up, and plank tests were compared between male and female groups, a significant difference was found in the sit-up parameter ($p>0.05$) (Table 1).

The comparison of the SLHT parameters of the athletes between dominant and non-dominant sides is presented in Table 2. While there was no significant difference in SH value between the sides in males, there was no significant difference in MRH in females ($p>0.05$). While there was a significant difference in TH, CH, MSTH, and MRH between the sides in males, a statistically significant difference was found in SH, TH, CH, and MSTH parameters in females ($p<0.05$).

When SLHT LSIs were compared between male and female groups, no statistically significant difference was found in all parameters ($p>0.05$) (Table 3).

This study evaluated the differences between male and female volleyball players in upper and lower extremity strength. As a result of the statistics between the groups, there was a significant difference between the shuttle test value ($p>0.05$). The reason for this is that women have some disadvantages, such as physiologically smaller bodies, less skeletal muscle mass, and more body fat percentage than men. In general, assuming that the percentage of upper extremity muscle mass of men is higher than that of women, it appears that gender affects strength due to the difference in strength that occurs in exercises using these muscles. Researchers have evaluated lower and upper extremity strength in athletes through different hypotheses. Different findings and interpretations emerged when the studies were evaluated together with our current study. In one study, the effect of 8-week core training on balance, muscle strength, speed, and agility performances was examined, and it was revealed that core strength had a positive effect on these parameters [22]. In a study involving 24 male tennis players, the effect of core stabilization exercises on the service speed in tennis was examined, and it was observed that the core balance statistical results were close to those of male volleyball players [23]. She investigated the chronic effects of core training on vertical jump capacity and balance in 12-14-year-

old female volleyball players. She applied normal volleyball training and core training programs in addition to normal volleyball training for 60 minutes three days a week for eight weeks. As a result of the 8-week training program, positive improvements were observed in the vertical jump test results of the volleyball players in the study group [24]. Unlike these studies, in a study comparing the effects of balance and core stabilization exercises on proprioception and trunk endurance in female soccer players [25], the plank parameter was found to be lower than the measurements of volleyball players in our study. When the training of the two branches was compared, it was expected that the upper extremity strength of soccer players would be better than that of volleyball players. However, the opposite situation was encountered in these measurements. We can interpret the reason for this as less strength training in training intensity and content. When we examined the other findings we obtained and similar studies, test-retest reliability and discriminatory ability of forward, medial, and rotational single-leg jump tests were examined together for men and women [19]. Although TAA and UAA measurement results supported our study, serious differences were observed in our MRA and MTUA values. The relationship between functional dimorphism and different lower extremity strength tests in young elite judo players was examined [26]. Close results were found between the pre-test results of the measurements and the values of male volleyball players, which supports our study [27] who evaluated the strength between the two legs in anterior cruciate ligament injuries by looking at their FTPs, found that the measurements obtained as a result of jumps with the non-injured side were lower than the results in our study. This is because a knee injury affects the force in the movements, no matter how intense the other knee is. In a similar study, the effect of 8-week core training on balance, muscle strength, speed, and agility performances was examined, and it was found that core strength had a positive effect on these parameters (Aydın, 2019). In a study involving 24 male tennis players, the effect of core stabilization exercises on the service speed in tennis games was examined, and it was observed that the results of core balance statistics were close to those of male volleyball players [23].

4. Conclusions

In our study, while similar results were observed between genders, men showed better results in the shuttle test. In our study, there is a difference only in the shuttle test, while similar results are seen between genders in general, which may be due to differences in training intensity. However, the subjects are from a single branch. In line with the results of our study, while we observe that gender differences in the same branch can directly affect the lower and upper extremity strength, we conclude that training content and intensity significantly affect athlete strength in studies conducted on athletes of the same gender in different branches. We think that evaluating gender differences within and between branches by including different branches and different measurement methods in the evaluation and taking into account the training levels in future studies will provide helpful information to the literature.

Conflict of interest

The authors declare no conflict of interests. All authors read and approved final version of the paper.

Authors Contribution

All authors contributed equally in this paper.

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	Women Mean±SD (%)	min±max	Men Mean±SD (%)	min±max
Age (year)	17.36±1.43	16±20	18.38±1.59	16±20
Height(cm)	166.82±5.98	1.54±1.73	179.88±4.15	1.73±1.86
Weight (kg)	56.82±8.80	45±53	67±85	68.25±10.97
BMI (kg/m2)	20.35±2.41	16.65±19.40	21.01±2.70	23.18±25.38
Training Experience (year)	5±1.78	3±8	6±1.92	4±10

Table 1: Patient demographic characteristics

	Women	Men	Between group
	Mean ± SD (%)	Mean ± SD (%)	
PUSH UPS	12.60±5.74	23.78±7.09	.225
SIT-UPS	13.20±3.46	23.00±7.75	.044*
PLANK	90.10±67.86	181.44±85.69	.161

Table 2: Comparison of push up, sit-up and plank test between men and women

	Women			Men		
	Dominant	Non- dominant		Dominant	Non-dominant	
(cm)	Mean±SD	Mean±SD	P	Mean±SD	Mean±SD	P
SH	136,73±30,34	153,91±79,29	,000**	196,38±196,38	196,38±24,08	,290
TH	398,55±132,36	418±59,5	,005*	560±60,79	580±79,29	,003*
CH	294,91±71,60	287,64±71,77	,001*	433,63±86,24	479,38±89,53	,000**
MSTH	467,75±80,7	284,55±65,65	,001*	467,75±80,77	438,38±92,94	.002*
MRH	109,64±28,7	106,45±22,23	,314	167,38±19,19	151,63±25,54	.043*

Table 3: Comparison of dominant and non-dominant sides of SLHTs

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