Turkish Journal of Sport and Exercise
http://dergipark.gov.tr/tsed
Year: 2019 - Volume: 21 - Issue: 1- Pages: 182-187
DOI :10.15314/tsed.513422

ISSN: 2147-5652

The relationship of wrist and shoulder joint isokinetic strength and service and spike velocity in elite female volleyball players

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Abstract

The purpose of the study was to examine the relationship between isokinetic wrist and shoulder strength and service and spike velocity of the female volleyball players. Totally 34 female volleyball players participated into the study voluntarily. Wrist (60°s-1 and 90°s-1) and shoulder strength (60°s-1 and 180°s-1) of the volleyball players were determined with isokinetic dynamometer; and service and spike velocity was determined with radar device. Pearson Correlation Analysis was performed for determining the relationship between isokinetic wrist and shoulder strength and service and spike velocity of the volleyball players. As result of the statistical analysis, whereas no significant relationship was determined between wrist and shoulder isokinetic strength and service and spike velocities of the female volleyball players ($p<0,05$), positive significant relationship was found between wrist and shoulder isokinetic strengths ($p<0,05$). Considering these results, it was possible to mention that although service and spike velocities of the volleyball players were correlational with the upper extremity strength, only wrist or only shoulder strength did not increase the velocity of service and spike, and this appeared by the effect of all upper extremity and bodily muscles. Regarding this, it was considered that volleyball players should develop other variables (strengthening all upper extremity and bodily muscles, improving the technique of spiking, etc.) besides wrist and shoulder strength in order to improve their service and spike velocity.

Key words: Voleyball, spike speed, serve speed, wrist strenght, shoulder strenght, isokinetic strength

INTRODUCTION

One of the recent common targets in all branches of sports is to increase performance levels of the athletes to the highest ranks and to sustain at this level. The volleyball with a long history has been in a permanent change and development. A high level volleyball player makes vigorous efforts to bring technical skills to an excellent level starting from early ages. Elite level players aim to maintain their technical skills and physical fitness parameters they have at a high level during the session.

In volleyball, strength is a remarkable physical fitness parameter during the trainings and matches. Assessing the muscular force of the players carefully is important in terms of the reasons such as both increasing their individual performances and eliminating the possible of injury. The tests performed with isokinetic systems are frequently used for assessing the different muscle groups, providing reliable and objective digital results, and measuring the performance of the players (1). The muscles contracted during the isokinetic assessment meet with a resistance equal to the strength applied throughout all movement depth. Accordingly, this provides the opportunity for a reliable measurement without the risk of muscle, tendon and ligament injuries keeping in physiological loading limits.

Upper extremity is heavily used in volleyball. Shoulder joint is the most complex joint of the body providing the connection of upper extremity to the body and shoulder's taking numerous positions. The complex motions of hand appear as result of the correct operating of the harmony between balanced muscular system of the hand and central nervous system (2).

Service throwing technique in volleyball is a fundamental technique that is recurrently used by all players except from libero during the matches and trainings. The first attack of the teams in volleyball is regarded as the service (3). And spike, in volleyball, is significantly relational with the matching performance of the teams and the instrument for taking the highest score during the match (4,5). Success of the spike technique depends upon velocity and direction of the ball (6).

Elite level players aim to use technical skills they have as the most efficiently during the trainings and matches. In volleyball, service and spike techniques are remarkable in terms of the attack force of the teams. It has been considered that upper extremity strength of the players should be improved besides other variables in order to increase the velocity of ball while implementing these techniques. It has been noticed that there are limited number of studies carried out on shoulder joint isokinetic strength and ball velocity in volleyball (7,8). However, there have been no studies in the literature investigating the wrist joint and service and spike velocities.

The purpose of this study was to investigate the relationship between service velocity and spike velocity that had a remarkable significance in performance of the players and teams in volleyball, and to make contributions for the literature, trainers and players.

MATERIALS & METHODS

Into the study, 34 volunteer female volleyball players playing volleyball as licensed in Halk Bank female volleyball team and Halk Bank young female volleyball team as the members of 2017-2018 Vestel Venüs Sultans League participated. Demographical properties of the players were presented in Table 1. The players who had no injuries on wrist and shoulder joint within the last three months were included into the research. The tests were performed in off-days of the volleyball players, and the players were asked not to attend in any sportive activities 24 hours ago before the tests and the measurements for each player were performed at the same hours of the day. The approval for carrying out the research was taken from Gazi University Clinical Researches Ethical Committee.

Isokinetic strength measurements

Isokinetic strength measurements of the players who participated into the study were asministered with Cybex Humac Norm branded isokinetic dynamometer by the experienced physiotherapists of Gazi University, Faculty of Health Sciences. Before starting to the tests, the volleyball players did stretching exercises for 4-5 minutes for wrist and shoulder joints and warm-up exercises at low tempo for 5 minutes optionally on cycle ergometer or treadmill. After the warm-up program, the participants were taken to the device of the measurement one by one, and the device was adjusted according to the individual anthropometric properties of the experimental subjects. The body of the participant to be measured was fastened to the seat with the bands from leg femur medium sections, and the measurement was administered for the shoulder joint on dominant side and wrist on dominant side. Two different test protocols were administered for the wrist joint of the players who participated into the research. Concentric isokinetic strength at 90°s-1 angular velocity and eccentric isokinetic strength at 60°s-1 angular velocity was analyzed in dominant wrist joint of the volleyball players. The measurements were performed on wrist flexor and extensor direction. The tests were administered in 3 trials and 5 repetitions. One-minute breaks were taken between the tests, and 30-second resting period was taken while passing to the real test after the trial repetitions. Moreover, visual feedback was also provided to the participants. The measurement device was adjusted according to the individual anthropometric properties of the experiments for shoulder joint isokinetic strength measurement. The dynamometer axis was adjusted according to the dominant-side shoulder diagonal pattern. The gravity correction was provided for the players, and maximal isokinetic strengths on diagonal pattern at concentric 60°s-1 and 180°s-1 angular velocities were recorded.

Ball velocity measurements

Service and spike velocities of the players who participated into the study were measured

with pocket radar speed gun (USA) branded velocity measurement device. The velocity measurement device had ±1mph/sec sensitivity, and had radar property that could measure at 25/130 mph/sec. While administering the measurements, the players were asked to strike the ball with their maximum force in order to obtain the best results in service and spikes. Furthermore, the players were informed that the balls that did not fall into the playground would be included into the measurement, so that the anxiety towards throwing the ball out of the playground was tried to be revealed.

Anthropometric measurements

The height measurement was performed with standard steel stadiotmeter as barefoot with 0.1cm sensitivity; and the bodyweight was measured with Tanita Body Analysis System as barefoot having no metals on the body.

Data Analysis

The data obtained at the end of the research were analyzed using SPSS (Statistical Package for Social Sciences) for Windows 22,0 statistical software. For assessing the data, maximum value, minimum value, arithmetic average and standard deviation were used as the descriptive statistics. Pearson correlation test was performed for all variables in the research. In terms of the level of significance, the results at the level of $p<0,05$ were accepted to be significant, and the ones at the level of $p<0,05$ were regarded to be insignifant.

RESULTS

Table 1. Demographical and anthropometric properties of the players

Physical properties	Mean	Sd
Age (year)	19.76	4.76
Height (cm)	181,76	8.59
Body weight (kg)	67.70	9.13

Table 2. Wrist and shoulder joint isokinetic strength values of the female volleyball players

	Wrist E. 60°s^{-1} (BW%)	Wrist F. 60°s^{-1} (BW%)	Wrist E. 90°s^{-1} (BW%)	Wrist F. 90°s^{-1} (BW%)	D. away 60°s^{-1} (BW%)	D. toward 60°s^{-1} (BW%)	D. away 180°s^{-1} (BW%)	D. toward 180°s^{-1} (BW%)
Mean	28.55	38.89	11.40	18.90	83.97	109.38	73.29	94.80
Sd	8.84	11.43	4.27	5.74	31.69	26.72	21.57	28.10

E. E. = Eccentric Extension E. F. = Eccentric Flexion C. E. = Concentric Extension C. F. = Concentric Flexion D. Away = Diagonal away. D.Toward = Diagonal toward %BW = Mean Peak Torque.

Table 3. Service and spike velocity values of the volleyball players

(mph/h)	Min	Max	Mean ± Sd
Dservice V	30.00	50.00	42.14±4.25
Dspike V	31.00	50.00	43.58±4.07

Dservice V: Dominant service velocity Dspike V: Dominant spike velocity

Table 4. The values of relationship between service velocity and spike velocity of the female volleyball players

Variables		Wrist Conc. PTE	Wrist Conc. PTF	Wrist Ext. PTE	Wrist Ext. PTF	Shoulder 60°s^{-1} PTA	Shoulder 60°s^{-1} PTT	Shoulder 180°s^{-1} PTA	Shoulder 180°s^{-1} PTT
Service	r	.,154	-.082	-.063	.050	-.246	-.105	-.265	-.041
Velocity	p	.417	.666	.745	.796	.174	.566	.143	.826
Spike	r	-.321	-.330	-.089	.012	-.248	.006	-.262	-.007
Velocity	p	.084	.075	.644	.953	.171	.975	.148	.971

$p<0.05$

No significant relationship value was determined between wrist concentric and eccentric isokinetic strengths and service and spike velocities of the female volleyball players (p<0,05). And a significant relationship value could not be determined between service and spike velocities and diagonal shoulder isokinetic strengths of the players (p<0,05).

Table 5. The values of relationship between wrist concentric isokinetic strength and shoulder joint isokinetic strength

Variables		Shoulder 60°s-1 PT Away	Shoulder 60°s-1 PT Toward	Shoulder 180°s-1 PT Away	Shoulder 180°s-1 PT Toward
Hand Conc.	r	.705**	.311	.668**	.167
PTE	p	.000	.107	.000	.395
Hand Conc.	r	.480**	.104	.633	.014
PTF	p	.010	.597	.000	.945

p<0.05

DISCUSSION

In this research, no significant relationship was determined between wrist and shoulder muscles' isokinetic strength, separately, in female volleyball players and service and spike velocities. However, a positive significant relationship was found between wrist and shoulder muscles' isokinetic strengths.

When the relationship between service velocity and wrist isokinetic strength values of the high-level players was analyzed, no significant relationship (p<0,05) was determined between service velocity (90°s-1) concentric extension and flexion strength and eccentric extension and flexion strength (60°s-1). This result did not prove the hypothesis that a player with high wrist isokinetic strength could make a service faster. It was possible to mention as the reason for this that service velocity did not only arisen from the wrist joint but also from shoulder arc, body and lower extremity muscles.

When the relationship between service velocity and shoulder isokinetic strength values of the players was analyzed, no significant relationship was found between diagonal shoulder isokinetic strength at 60°s-1 angular velocity and diagonal shoulder isokinetic strength at 180°s-1 angular velocity (p<0,05). We considered that such a result could be arisen from several reasons. These could be listed as the diagonal pattern with which the isokinetic strengths of the players were measured, administering the measurements at a sitting position, and therefore limiting all other joint and muscular functions during the measurements. Due to the linking of the lower extremity and bodily muscles to the shoulder complex, more than 50% of the energy during the service and spike is produced by lower extremity ad bodily muscles. Therefore, considering all components of the kinetic chain is necessary for performing severe overhead activities successfully and returning to sports (9).

When the relationship between spike velocity and wrist isokinetic strength of the elite female volleyball players was analyzed, no significant relationship was determined between concentric (90°s-1) extension and flexion strength and eccentric (60°s-1) extension and flexion strength (p<0,05). When the literature was revised, no study was noticed on wrist joint isokinetic strength and ball velocity in volleyball. It was also noticed that the studies carried out on the wrist were generally related to the patients and post-operation implementations. For that reason, it was possible to mention that this research on wrist isokinetic strength and service and spike velocities would fill an important void in the literature and shed a light on subsequent studies to be carried out on this.

Some interesting results were noticed to be obtained in some studies investigating other factors apart from strength that affected the spike velocity. In one of these researches, Newell and Lauder (10) expressed that hand and wrist motion in spike was one of the important factors affecting the ball velocity. It was remarkable in this research that the factors that affected ball velocity during the spike were hand and wrist motions rather than the strength.

When the relationship between spike velocities and shoulder isokinetic strength of the players was analyzed, no statistically significant relationship was determined between diagonal shoulder isokinetic strength at 60°s-1 angular velocity and diagonal shoulder isokinetic strength at 180°s-1 angular

velocity (p<0,05). The primary target of the shoulder complex is the positioning of the hand loosely in daily living activities. In overhead sportive activities such as spike or service, the secondary function of the shoulder was to transfer the power of body and leg's big and strong muscles to the leg, forearm and hand muscles (11). Spike in volleyball not only actualized with the functioning of the muscles surrounding the shoulder but also with muscle-joint activation covering all upper extremity, body and lower extremity. Accordingly, its not being relational only with the shoulder joint could be explained with these reasons.

In their study with the football players, Forthomme et al (12) could not find a significant relationship between concentric dominant shoulder internal rotation isokinetic strength and spike velocity at 240°s-1 and 400°s-1 angular velocities as a fact proving our result. However, they also indicated a significant relationship between dominant shoulder internal rotation concentric isokinetic strength and spike velocity at 60°s-1 angular velocity in the same study. In another study, Valades et al (13) investigated the relationship between ball velocity, anthropometric properties and strengths of the volleyball players during a session. The results obtained at the end of this research supported the results of our study; it was determined that although there was increase at strength in the players, this increase could not reflect the velocity of throwing the ball. While measuring the strength with isokinetic dynamometer, the angular velocity could mostly be measured up to 500 degrees (14). However, in his study, Baudin (15) mentioned that dominant leg angular velocity was found to be 975.99±155.78°s-1 as average during the spike.

There was a positive relationship (p<0,05) between wrist (90°s-1) concentric isokinetic strength extension and flexion values and shoulder isokinetic strength (60°s-1 and 180°s-1) on diagonal away direction in elite female volleyball players. Positive significant values were obtained at different angular velocities and directions between wrist and shoulder isokinetic strengths of the players; so that it was noticed that a player with high wrist isokinetic strength value had similarly high shoulder isokinetic strength value. In branch of volleyball, a strong upper extremity has a key role in success. The increase at the strength of elbow and wrist muscles has been expected when the strength appears in shoulder muscles as result of the strength trainings. The positive relationships determined in this research indicated this fact. In reference to this result, strong proximal structures in players could be considered as providing a basis for the strength of distal segments.

The strength as one of the important components of sportive performance has been implemented commonly in training programs by the trainers due to different reasons such as improving the performance quality of the player and decreasing the possible sports injuries. It was possible to mention that the trainers in volleyball should consider the other factors affecting these techniques instead of focusing only on strength trainings for improving the service and spike velocities of the players. In fact, it was concluded in some studies in the literature that the factors such as missing technical components, anxiety, motivation, and sports age affected the ball velocity (16,17). Jones and Hardly (18) argued that sportive performance did not only depend on physiologic and biomechanic factors such as technique but also depended on the psychological factors. In another study, it was concluded that increase at ball velocity appeared as result of the increase at movement in upper extremity depending upon the increase in pelvis, body and shoulder rotation in arm grip and acceleration stages (19).

Considering these results, it was recommended that not only wrist and shoulder muscles should be focused in order to improve the spike and service velocity performances of the female volleyball players, but also all other factors possible to affect the performance should be regarded.

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