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Relationship Between Anthropometric Parameters with Vertical Jump in Male Elite Volleyball Players Due to Game's Position

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Abstract: Vertical jump is one of the necessary components in performing spike and block skills in volleyball. Recent study was performed to determine relationship between anthropometric properties with vertical jump on 40 male elite volleyball players (27.93±3.92 years old and 8±1.53 years sport history) which at least played for 4 years in Iran premier league. Individual satisfaction and information forms were completed. 42 anthropometric parameters were measured. In order to decrease parameters covering the same measurements among 42 anthropometric properties, multiple correlation were applied and parameters with coefficient higher than 0.8 were selected for further analysis, so number of parameters decreased to 17. Using principle component analysis method on 17 parameters, three main components including 70% of data variance were extracted. In the main components, parameters with coefficient more than 0.7 including weight, seated height in fixture, shank length, foot length, torso circumference at hip level, maximum calf circumference, abdomen fat, middle tight circumference and tight length were used for further analysis. The difference in distance between the standing reach height and the jump height was measured as the vertical jump records. To determine differences between vertical jump records and also relationship between anthropometric properties with vertical jumps, one way variance analysis (F-Test) and regression coefficients were used. Results show that spikers and liberos have the highest and the lowest vertical jump. There are significant differences between vertical jump of spikers and liberos, also between setters and liberos, but there are no significant differences between vertical jump of spikers and setters. According to the study, there is significant relationship between vertical jumps with shank length, maximum calf circumference, foot length for spikers and setters, also tight circumference and weight for liberos. Considering anthropometric parameters as well as training methods due to game's position seems to be necessary for volleyball players to perform spike and block successfully.

Key words: Vertical jump · Anthropometric parameters · Volleyball players

INTRODUCTION

Anthropometric properties of athletes represent important prerequisite for successful presence at the same sport, effecting athlete's performance and are necessary in order to gain excellent performance of sports skills [1-4]. It is assumed special sports' success is directly related to athlete's anthropometric characteristics of the same sport [2,4-6]. Volleyball, as one of the most amazing sports, includes fast movements, jumpings, landings and sudden shifts which need high power and strength for optimized performance [7]. Physical structures of volleyball players are mainly assessed through measuring anthropometric parameters such as standing height, Body mass index and some other physical factors related to performance skills like jumping ability, agility, strength and endurance [1-4, 8-9]. Numerous studies have investigated anthropometric parameters of volleyball players, demonstrating higher standing height and lean muscle mass, lower seated height, longer hands, thinner hip and ankle, thicker shin, longer Achilles tendon and longer lower extremity are the most important ones [1-12]. Beside physical ability, muscle strength and power, agility, flexibility, individual techniques and teamwork capabilities, anthropometric parameters are effective in success of volleyball players [1,2,9,13]. In many investigations, volleyball is introduced

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as a power sport in which optimized performance of players are mainly related to the amount of jumping [3-5,12-16]. One of the main purposes of volleyball players in a match is superiority on the net against the other team and players with higher jumping ability have the advantage comparing to the others [13]. Lower extremity power and vertical jumping are of the significant indexes of volleyball players to be successful [17].

Usually in a volleyball game, Attack and Block skills constitute approximately 45% of total movements and reflexes and almost 80% of points are gained through these techniques [16]. Better performance of spike and Block as well as jumping service are dependent to the amount of height which players can reach [13]. Studies show that there is significant correlation between vertical jump ability with success rate of spike and block in volleyball games [12]. One of the most important purposes of training is improving muscle strength and power for volleyball players [16,18]. Volleyball players' excellent performances are widely associated with efficiency of jumping or lower extremity explosive power which finally introduce vertical jump as one of the most important characteristics of physical fitness in volleyball players [9]. Like other power sport, muscle power seems to be a vital component for volleyball players [18]. Relationships between anthropometric parameters with physical performance of volleyball players have been studie in some investigations. Paolo *et al*. 2007 reported that beach volleyball players' anthropometric parameters are smaller comparing to the gym volleyball players one [8]. Results of Ciccaron 2008 showed that there is significant relationship between anthropometric parameters and game's position with biomechanical properties of volleyball players [14]. Stamm *et al*. 2003 reported that anthropometric parameters have significant effect on performing of all technical and tactical components especially block and Spike [15]. You 2003 reported hands length have significant correlation with technical skills of volleyball during ball contact phase [19]. Ling *et al*. 2007 reported that waist circumference has negative correlation with function of abdominal muscles in volleyball players [20]. Duncan *et al*. 2007 showed that seated height to standing height ratio is considered as an effective scale on center of mass which has positive effects on agility and fast movement but negative factor for jumping ability [1]. Voight *et al*. 2003 reported that hands muscle strength has positive relationship with velocity of hands' twisting and finally consequent force transmitted to the ball [16].

Zhang 2010 assessed anthropometric profiles of Chinese elite volleyball players and their relationships with physical features but no relationships were derived [9]. Davis *et al*. 2003 studied predictor factors which determine vertical jumping and physical parameters of amateur athletes and no significant relationship between some anthropometric parameters such as fat, lower extremity length with jumping ability [21].

Review on studies shows that most of investigations are concentrated on anthropometric parameters and physical characteristics of volleyball players in different game's position. Purpose of this study is to determine relationship between anthropometric parameters with vertical jump of male elite volleyball players of Iran.

Methodology: Recent study was performed to determine relationship between anthropometric properties with vertical jump on 40 male elite volleyball players (27.93±3.92 years old and 8±1.53 years sport history] which at least played for 4 years in Iran premier league. Individual satisfaction and information forms were completed by subjects in the players' residence in national team camp in addition to describing purposes and necessities of this study. 42 anthropometric parameters (standing height, weight, standing acromion height, standing knee height, seated height in fixture, seated hip breadth, seated ankle distance (horizontal), head width, head depth, head length, head circumference, two hands distance (distance between tip of left to right of 3rd finger in frontal plan), torso width at nipple height, torso circumference at nipple height, torso width at umbilicus, torso circumference at umbilicus, torso width at hip level, torso circumference at hip level, upper arm circumference at axilla, maximum upper arm circumference, forearm length, elbow circumference, maximum forearm circumference, elbow width, wrist width, wrist circumference, hand length (wrist to tip of 3rd finger), tight length, middle tight circumference, femoral epycondyle (knee) width, knee circumference, shank length, maximum calf circumference, foot length, foot arch circumference, malleolus width, triceps fat, sub scapular fat, calf fat, tight fat and abdomen fat) were measured using caliper and flexible tape meter. In order to decrease parameters covering the same measurements among 42 anthropometric properties, multiple correlation were applied and parameters with coefficient higher than 0.8 were selected for further analysis, so number of parameters decreased to 17. Using principle component

analysis method on 17 parameters, three main components including 70% of data variance were extracted. In the main components, parameters with coefficient more than 0.7 including weight, seated height in fixture, shank length, foot length, torso circumference at hip level, maximum calf circumference, abdomen fat, middle tight circumference and tight length were used for further analysis. To measure Vertical jump records, first, confidence of appropriate physical condition were achieved, correct process of measurement were described for them and then subjects warmed up completely to perform the test. Correct process of test was described and subject stands side on to a wall and reaches up with the hand closest to the wall. Keeping the feet flat on the ground, the point of the fingertips is marked or recorded. This is called the standing reach height. The athlete then stands away from the wall and jumps vertically as high as possible using both arms and legs to assist in projecting the body upwards. Attempt to touch the wall at the highest point of the jump. The difference in distance between the standing reach height and the jump height is the score. The best of three attempts is recorded. After gathering vertical jump's data, subjects divided to three separate groups according to their game's position including spikers, setters and liberos. To determine differences between vertical jump records of spikers, setters and liberos one way variance analysis (F-Test) was used, also, in order to determine relationship between anthropometric properties with vertical jumps regression coefficients were used.

RESULTS

Among the subjects, 25% were setters, 50% were spikers and 25% were liberos. Average and Standard deviation of subjects' vertical jump is shown in figure 1.

According to the Figure 1, spikers and liberos have the highest and the lowest vertical jump. Figure 2 show variance percentage of components derived from component analysis. Totally, three main extracted components include 68.3% of total information variance.

Table 1 show coefficients resulted from principal components analysis of extracted parameters.

According to tables 2 and 3 there is significant differences between vertical jump of spikers and liberos, also between setters and liberos, but there is no significant difference between vertical jump of spikers and setters. Differences seem to be logical and explainable according to the game's position and duty of players in various positions. Table 4 show results of multiple regression coefficients between extracted parameters from principal component analysis and vertical jump of subjects in various games' positions.

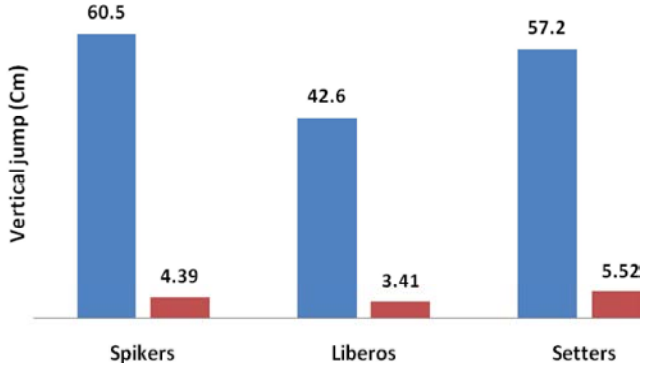

Fig. 1: Averages and Standard Deviations of Vertical jumps due to game's position

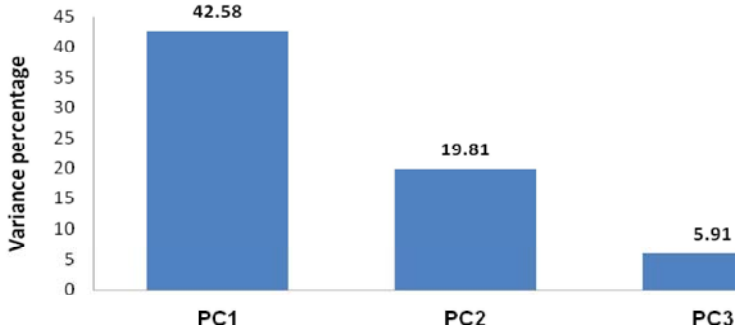

Fig. 2: Variances percentage of extracted parameters from principle component analysis

Table 1: coefficients of extracted parameters from triple components using principle components analysis

PC1	PC2	PC3
Shank length (0.91)	Abdomen fat (0.88)	Tight length (0.75)
Seated height in fixture (0.89)	Maximum calf circumference (0.82)	----------
weight (0.85)	Middle tight circumference (0.79)	----------
Foot length (0.82)	----------	----------
Torso circumference at hip level (0.81)	----------	----------

Table 2: Results of one way variance analysis of subjects' vertical jumps

	Sum of squares	Df	Squares average	F	Sign.
Between Groups	2204.05	2	1102.03	12.52*	2.34
Within groups	3256.45	37	88.01		
Total	5460.5	39	140.01		

*Significant differences $p \leq 0.05$

Table 3: Results of Scheffe Tests according to game's position

	Scheffe Score	Sign.
Spikers jump--------Setters jump	1.64	2.16
Spikers jump--------Liberos jump	7.97*	2.16
Setters jump--------Liberos jump	6.54*	2.16

Table 4: Regression coefficients (β) between anthropometric parameters and vertical jump of male elite Spikers

	Unstd. Coefficients		Std. Coefficients
Spikers parameters	Beta	Std. Error	Beta
Constant	27.31	58.54	--------
Foot length	0.42	2.79	0.08
Seated height in fixture	-0.13	0.46	-0.12
Weight	-0.39	0.53	-0.57
Shank length	0.98	0.64	0.69
Torso circumference at hip level	-0.05	0.67	-0.37
Abdomen fat	-3.34	3.79	-0.33
Maximum calf circumference	0.03	1.20	0.54
Middle tight circumference	0.43	0.48	0.43
Tight length	0.26	0.45	0.21

Table 4: Regression coefficients (β) between anthropometric parameters and vertical jump of male elite Setters

	Unstd. Coefficients		Std. Coefficients
Setters parameters	Beta	Std. Error	Beta
Constant	14.33	0.00	--------
Foot length	26.07	0.00	7.92
Seated height in fixture	-7.04	0.00	-4.77
Weight	-9.3	0.00	-10.97
Shank length	15.02	0.00	7.92
Torso circumference at hip level	2.64	0.00	1.55
Abdomen fat	-17.25	0.00	-1.42
Maximum calf circumference	10.92	0.00	8.10
Middle tight circumference	0.24	0.00	0.22
Tight length	-10.17	0.00	-5.30

Table 4-Regression coefficients (β) between anthropometric parameters and vertical jump of male elite Liberos

	Unstd. Coefficients		Std. Coefficients
Liberos parameters	Beta	Std. Error	Beta
Constant	-61.94	0.00	--------
Foot length	2.29	0.00	0.45
Seated height in fixture	0.27	0.00	0.35
Weight	-1.58	0.00	-1.36
Shank length	1.31	0.00	0.57
Torso circumference at hip level	1.22	0.00	0.66
Abdomen fat	3.14	0.00	0.23
Maximum calf circumference	-1.30	0.00	8.10
Middle tight circumference	2.39	0.00	1.19
Tight length	-1.55	0.00	-0.65

According to table 4, estimated equation between vertical jump and anthropometric parameters extracted from principal component analysis for spikers is presented as:

- Vertical jump records = $27.31 + 0.42X_1 - 0.13X_2 - 0.39X_3 + 0.98X_4 - 0.05X_5 - 3.34X_6 + 0.03X_7 + 0.43X_8 + 0.26X_9$

In which
X_1: Foot length, X_2: Seated height in fixture, X_3: Weight, X_4: shank length, X_5: torso circumference at hip level, X_6: abdomen fat, X_7: Maximum calf circumference, X_8: middle tight circumference, X_9: tight length

The most important parameters affecting on vertical jumps are weight, shank length and maximum calf circumferences which weight has negative effect and the others have positive effect on vertical jumps' records of male elite spikers.

Vertical jump's record of setters can be predicted as below:

Vertical Jump = $14.33 + 26.07X_1 - 7.04X_2 - 9.3X_3 + 15.02X_4 + 2.64X_5 - 17.25X_6 + 10.92X7 + 0.24X_8 - 10.17X_9$

X_1: Foot length, X_2: Seated height in fixture, X_3: Weight, X_4: shank length, X_5: torso circumference at hip level, X_6: abdomen fat, X_7: Maximum calf circumference, X_8: middle tight circumference, X_9: tight length

Among these parameters, there is significant relationship between vertical jump with Weight, foot length, Shank length and maximum calf circumference.

Finally Extracted equation for vertical jump and anthropometric parameters of liberos is:

Vertical jump $=-61.94 + 2.29X_1 + 0.27X_2 - 1.58X_3 + 1.31X_4 + 1.22X_5 + 3.14X_6 - 1.30X_7 + 2.39X_8 - 1.55X_9$

Which:
X_1: Foot length, X_2: Seated height in fixture, X_3: Weight, X_4: shank length, X_5: torso circumference at hip level, X_6: abdomen fat, X_7: Maximum calf circumference, X_8: middle tight circumference, X_9: tight length

In liberos there is significant relationship between weight, maximum calf circumference and tight length with vertical jump.

Consequently, there is significant relationship between parameters such as weight, shank length, maximum calf circumference, foot length, tight length and vertical jump of male elite volleyball players.

DISCUSSION

Anthropometric properties as well as appropriate physical fitness are important prerequisites for outstanding performance of sports skills and play a distinguished role in sports successful achievements [14]. Thus, physical structures provide a substructure in order to form and improve motor techniques specially various sports physical performances.

volleyball, as a power sport, demand high number of jumps for players to perform spikes and blocks, so the ability of jumping is introduced as an important factor determining physical fitness of volleyball players through assessing lower extremity and abdominal explosive power.

Because there is no other similar study in relationship between vertical jump and anthropometric parameters upon games position of volleyball players, it is not possible to compare the results. Results of study are agreement with the results of Davis *et al*. (2003) and disagreement with Zhang 2010. Davis *et al*. (2003) demonstrated that there is significant relationship with some anthropometric parameters such as foot length, fat and circumference of some joints, although it was performed on amateur athletes [21]. Maybe one of disagreements reasons with Zhang (2010) is differences in gender. Zhangs study was performed on Chinese elite athletes. It is remarkable that jumping styles in females and males are different, with greater extension of knee joint and back and lower plantar flexion of ankle in females comparing to males [22]. According to results, among the extracted anthropometric parameters, weight, shank length, maximum calf circumference, seated height, torso circumference in hip level and tight length are the most significant related parameters with vertical jumping of male elite volleyball players. There is great similarity between effective parameters on vertical jumping of spikers and setters which are not noticeable in liberos. The differences in parameters could be explained through games position of players. The main purpose of volleyball players is achieving greater height on the net [17]. Nowadays players who are able to achieve greater height during performing spike and block, as the most valuable skills in volleyball have the advantages comparing to other players which is possible with the ability of higher jumping [13]. Liberos as the backline players participate in receive and digging during the match but setters and spikers play in front of the net, performing spike and block [1]. It is clear that higher jumping is not advantage for liberos whereas it is necessary for spikers and blockers. Review of table 1 shows that there is significant difference between vertical jumping of liberos with spikers and blockers.

Amount of vertical jump is affected by various physiological and biomechanical parameters [15]. Vertical jump totally is determined through vertical velocity components and gravity during takeoff phase. Jumping process requires an external force as the ground reaction force which is the result of generated torques transmission to the ground. Joints Torque is generated from muscle contraction during structure displacement. Final torque in a joint is difference of contractile forces in agonist and antagonist muscles. Moreover amount of force is also dependent to muscular properties. Ground reaction force should be greater than weight. Then, it will be transmitted to the body and determine velocity of COM. An appropriate vertical jump could be explained through Newton second law, direct dependence of body acceleration with mass and third law, action and reaction law. A vertical jump will exert a reaction force, equal and in the opposite direction, caused by applied force on the ground, called as acceleration of the COM. Vertical jump performance is determined through displacement magnitude and direction of Com velocity in take off phase and is measured by COM displacement. Finally, consequent of five parameters including velocity, joint angle, COM height, air resistance and gravity force, all in take off phase, will lead to maximum of vertical jump [22]. But dependence of vertical jump with anthropometric and physical parameters, also, should be noticed. As regression tables show shank length, maximum of calf circumference and weight are as the most important anthropometric parameters affecting vertical jump for spikers and setters. It is remarkable that a high vertical jump requires forces greater than gravity as the negative force, which is advantage for a volleyball player with lower weight comparing to heavy ones. Fat, also, has positive correlation with mass and body weight. More fat causes more body weight that requires greater forces in order to overcome gravity force [9,22]. Greater calf circumference has significant correlation with jump in spikers and setters. Muscle size effects force producing and jump performance. Perhaps, greater physiological cross section of muscles, contains more sarcomers contributing in muscular contractile which leads to more cross bridges foundation and finally greater force production. Greater shank length and foot length in jumpers causes a grater torque for a reaction force in ankle joint, consequently more lever length and more transmitted force. Also, greater Achilles tendon and greater produced power in a short or quick. Ratio of seated height in fixture to standing height is determinant of lower extremity to upper extremity. Lower amount of this ratio in volleyball players shows higher lower extremity, longer bones in lower extremity and finally higher COM [1, 4,5,7,9]. Higher COM in jumpers is an advantage because it helps them to make more acceleration and force in a longer distance of the body, so by means of displacement, transmission of COM in vertical direction is easier [9,22].

CONCLUSION

Maximum vertical jump is one of the necessary components in performing spike and block skills in volleyball. According to the study, there is significant relationship between vertical jumps with shank length, maximum calf circumference, foot length for spikers and setters, also tight circumference and weight for liberos. However, anthropometric parameters are effective on vertical jumps on different games position in volleyball players. Considering anthropometric parameters as well as training methods due to games position seems to be necessary for volleyball players.

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