

Evaluation of the Relationship between Explosive Power and Anthropometric and Body Composition Indices in Female Volleyball Players

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Abstract

Background: Volleyball is known as sport that requires high physical fitness, including muscle power, agility and reaction; hence, body composition and anthropometric features play important roles in this field. The purpose of this study was to investigate the relationship between anthropometric and body composition indices with lower limb explosive power in female volleyball players. **Method:** This correlational study was conducted in which 16 semi-professional female volleyball players with an average age of 20.4 ± 1.34 years and BMI of 22.09 ± 3.42 kg/m² voluntarily participated. All volleyball players had a history of participation in the Tehran province volleyball league. First, data were collected and recorded by demographic questionnaire. Then, the body composition (fat percentage, muscle mass, visceral fat) was measured and recorded in the 3-hours fasting condition by body analysis device (OMRUN Bf511). Finally, Sargent Vertical Jump Test was used to evaluate explosive power of the lower limb muscles. **Results:** Pearson correlation coefficient was used at the significant level $p < 0.05$ for statistical analysis. The results indicated a significant positive correlation between muscle mass and lower limb explosive power ($P < 0.02$) and a significant negative correlation between explosive power and fat percentage ($p < 0.05$). Also, a significant positive relationship was found between height and explosive power of lower limb. **Conclusion:** The results of this study show that resistance training along with volleyball specific power training can increase the muscle mass as well as it is at the same time.

Keywords: Muscle mass, Explosive power, Sargent, Volleyball, Fat percentage

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INTRODUCTION

It is believed that success in any sport field is directly related to the anthropometric characteristics of athletes (Barut, Demirel, & Kıran, 2008; Gualdi-Russo & Zaccagni, 2001; Malousaris et al., 2008). In fact, they influence sports performance and they are essential for achievement of advanced sport skills (Duncan, Woodfield, & Al-Nakeeb, 2006). In addition to anthropometric indices, body composition is known as an important and vital factor in athletes performance (Acar & Eler, 2019; Aytek, 2007). Besides physiological characteristics of each sport such as duration, intensity, and predominant energy system during activity, the specific body composition of athletes is also necessary to reach their peak of performance. Recent studies suggest to measure various types of body composition and anthropometric indices such as fat percentage, muscle mass, total body water, bone mass, and body mass index (BMI), weight and height. However, the most important components of body composition related to performance in all sport fields are body fat percentage and muscle mass (Acar & Eler, 2019; Fattahi, Ameli, Sadeghi, & Mahmoodi 2012; Palao, Gutiérrez, & Frideres, 2008).

Many studies have reported a negative correlation between fat percentage and sport performance as well as positive correlation between muscle mass and vertical jump in volleyball players (Aytek, 2007; Nikolaidis, 2013). Many researchers have introduced volleyball as a power sport which whose players' success mainly associated with their jumping ability (Ciccarone et al., 2008; Gualdi-Russo & Zaccagni, 2001; Malousaris et al., 2008; Mohamed, 2010; Reeberg Stanganelli, Dourado, Oncken, Mançan, & Costa, 2008; Stamm et al., 2003; Voigt & Vetter, 2003; Xing, Qi, & Sun, 2006). Also, one of the most important goals of volleyball players is superiority on the tour during the competition, those tall players with more jumping ability would have more chance of success in this sport (Ciccarone et al., 2008; Stec & Smulsky, 2007).

In addition, during a volleyball game, the skills of Spike (Attack) and Block (Defense) account for about 45% of the movements and reactions, and they also constitute almost 80% of the game's score (Voigt & Vetter, 2003). The favorable performance in the Spike and Block skills, mostly depends on the vertical jump height of players which is actually dependent on volleyball players' explosive power (Ciccarone et al., 2008).

Accordingly, the results of Xing et al. (2006) study showed a strong and positive relationship between vertical jump and the success rate of volleyball players in the Spike and Block techniques (Xing et al., 2006). In addition, Zhang (2010), in a cross-sectional study, showed that sport performance of elite volleyball players has been closely linked to the jump height or explosive power of these athletes, causes that explosive power of lower limb is considered as one of the most important indices of physical fitness in volleyball (Zhang, 2010).

However, several studies have examined the relationship between anthropometric indices and sport performance (Fattahi et al., 2012; Zhang, 2010). Acar & Eler (2019) reported a direct and significant relationship between muscle mass and lower limb explosive power. Also, the inverse effect of subcutaneous fat percentage on the optimal performance of athletes has been proven in numerous studies (Acar & Eler, 2019; Piucco & Santos, 2009; Shedlarski, 2011)

Regarding to the recent development of volleyball among Iranian women as well as few existence of studies among female volleyball players, few studies have been conducted on the relationship between anthropometric indices and body composition with sport performance. On the other hand, due to the explosive nature of volleyball and the vital role of anthropometric and physiological indices in talents identification, training schedule and the optimal performance of volleyball players, we assumed that factors such as height, weight, muscle mass, and subcutaneous fat percentage would have the relationship with explosive power of players. Therefore, the purpose of this study was to investigate the relationship between anthropometric indices and body composition with explosive power of lower limb among female volleyball players.

METHOD

Subjects

In this cross-sectional study, 16 females with a mean age of 20.4 ± 1.34 years and BMI of 22.09 ± 3.42 kg.m² participated voluntarily. All volleyball players had experienced two years of constant practice, at least three sessions per week and had a history of participation in Tehran Province volleyball league. At first, the individual's data were collected and recorded by a demographic questionnaire. The demographic questionnaire included history of training, various diseases (such as

diabetes, kidney, cardiovascular diseases etc.), injuries, lower range of motion and performance-enhancing supplements and drugs. One of the subjects was excluded from the research due to incomplete demographic questionnaire.

MEASUREMENTS

Body Composition

The evaluation of players' body composition was done, in 3-hour fasting state at 10am with minimal clothing by the exercise physiology laboratory assistant. Body composition indices such as muscle mass, subcutaneous fat percentage and body mass index were measured and recorded by OMRON (BF511) body composition analysis device. In this section, two subjects were excluded from the study due to the absence of fasting state and BMI above 27 kg.m².

Anthropometric Indices

The height of the subjects was measured and recorded by wall-sticker tape meter, without shoes. Also, the players' weight was measured and recorded by the OMRON digital scanner with a 0.01 g sensitivity, and minimal clothing.

Testing

Sargent jump test was used to assess the lower limb muscle power. Physical performance tests and body composition measurements were done on the same day. At the beginning of the session, the subjects warmed up for 10 minutes by brisk walking and few stretching exercise.

Sargent test

To measure vertical jump, player stood side on to a wall and reached up with the hand closest to the wall while keeping the feet flat on the ground then the point of the fingertips was marked. This is called the standing reach height. The player then stood away from the wall, and jumped vertically as high as possible using both arms and legs to assist the body upwards. The point of the jump was marked. The difference in distance between the standing reach height and the jump height is the players' vertical jump score. The subject performed the test three times and the best record was used for the final analysis (Salles, Vasconcellos, Salles, Fonseca, & Dantas, 2012). A 45-second rest was considered between each attempt. The reliability of the jumping tests ranged from 0.97 to

0.99 for Cronbach's alpha coefficients (Sattler, Sekulic, Hadzic, Uljevic, & Dervisevic, 2012).

RESULTS

Demographic characteristics and explosive power of subjects are presented in (Table 1).

Table 1: Descriptive and performance characteristics of subjects

Variables	Mean	Std. Deviation
Muscle mass (%)	28.97	3
Fat percentage (%)	30.29	6.25
BMI(kg/m ²)	22.09	3.42
Weight (kg)	62.78	12.68
Height (cm)	165.94	6.1
Explosive power (watt)	31.5	5.15

The results of Pearson correlation coefficient showed a significant positive correlation between muscle mass and lower limb explosive power ($P < 0.02$) and a significant negative correlation between explosive power and body fat percentage ($P < 0.05$). Also, there was a positive and significant correlation between height and explosive power of lower limb ($P < 0.05$). Table 2 shows the relationship between anthropometric indices and explosive power of subjects.

Table 2: Analysis of correlation between body composition and explosive power of subjects

variables	Explosive power	
	Pearson correlation	Sig (2-tailed)
Height	0.506	0.046*
Weight	0.007	0.981
BMI	-0.253	0.344
Fat percentage	-0.497	0.050*
Muscle mass	0.578	0.022*

(*) indicates $p < 0.05$

DISCUSSION

Anthropometric and physiological indices provide important feedback on planning, talents identification and performance prediction of female volleyball players. Despite development and progression of volleyball field among Iranian women, few studies have evaluated anthropometric indices and their relationship to the explosive power. In the present study, significant negative correlation between body fat percentage and lower limb explosive power of female volleyball players were found. The results of this study are consistent with several studies (Abidin & Adam, 2013; Acar & Eler, 2019; Aytek, 2007; Piucco & Santos, 2009; Shedlarski, 2011).

According to the Work formula, which is the product of force and distance, Athletes with higher percentage of subcutaneous fat have to work more than those who are slimmer for the same distances (Reiser, Rocheford, & Armstrong, 2006; Roschel et al., 2009). Therefore, by observing the diet and doing the appropriate exercises under the supervision of exercise physiologists, it is possible that by reducing the subcutaneous fat percentage, the explosive power and sport performance improves (Masanovic, Milosevic, & Corluka, 2018).

In addition, Chamorro & Lorenzo (2004) in a cross-sectional study, showed that according to the direct and inverse role of force and body mass in acceleration, the increase of fat percentages and consequently the increase of body mass, lead to decrease in sport performance includes fast and explosive movements (Chamorro & Lorenzo, 2004).

In the present study, there was a positive and significant correlation between muscle mass and lower limb explosive power of female volleyball players. The results of this study is in line with a study by Acar & Eler, (2019) (Acar & Eler, 2019; Aytek, 2007). Muscle mass, unlike fat mass, is recognized as a positive indices of sport performance; in other words, athletes with more muscle mass would have the ability to produce more force against the static and dynamic resistances (Malá, Malý, Záhalka, & Bunc, 2010).

On the other hand, Granados, Izquierdo, Ibañez, Bonnabau, and Gorostiaga (2007), showed that elite female volleyball players are more capable of producing force due to their more muscle mass (Granados et al., 2007). Moreover, regarding to the direct relationship of force production with acceleration, it can be argued that athletes with more

muscle mass have more ability to produce power, which ultimately leads to performance improvement in accelerated and explosive movements (Chamorro & Lorenzo, 2004).

In this regard, several studies have reported the positive relationship between muscle mass and force production in different athletes. In addition, since muscle power is the result of maximum force in a minimum amount of time, muscle mass can be considered as a vital factor in increasing volleyball performance (Shedlarski, 2011).

In the present study, a significant positive correlation was found between the height and explosive power of lower limb among the female volleyball players. This result is consistent with several findings (Aouadi et al., 2012; Fattahi et al., 2012; Zhang, 2010).

The vertical jump is affected by several physiological and biomechanical parameters. In fact, the amount of vertical jump depends on various factors such as the torque production and the external forces. According to the law of action and reaction, the productive torque in the joint is transmitted by the muscles to the ground and then the ground reaction force leads to the vertical jump.

Also, taller players jump higher than shorter ones due to the fact that they have longer levers and greater torques which produce more force and lead them to jumping higher which indicates better explosive power. (Fattahi et al., 2012; Patel, 2010).

In addition, the higher vertical jumps of taller players is due to their longer muscles which produce more force by the eccentric stretching in the first phase of jumping.

CONCLUSIONS

Regarding to the role of body composition and the height of players in explosive power, these two factors can be used to identify potential talented women in volleyball. Also, coaches can improve muscle mass and increase exercise performance by using resistance training in female volleyball annual periodization.

Table 3: Descriptive and performance characteristics of female volleyball players

Variables	Mean	Std. Deviation
Muscle mass	28.97	3
Fat percentage	30.29	6.25
BMI	22.09	3.42
Weight	62.78	12.68
Height	165.94	6.1
Explosive power	31.5	5.15

Table 4: Analysis of correlation between body composition and explosive power of volleyball players

variables	Explosive power	
	Pearson correlation	Sig(2-tailed)
Height	0.506	0.046*
Weight	0.007	0.981
BMI	-0.253	0.344
Fat percentage	-0.497	0.050*
Muscle mass	0.578	0.022*

(*) indicates $p < 0.05$

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بررسی ارتباط میان توان انفجاری و شاخص های آنترپومتریکی و ترکیب بدنی دختران والیبالیست

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چکیده

پیش زمینه: والیبال به عنوان رشته ورزشی که نیاز به آمادگی و مهارت جسمانی بالا اعم از توان انفجاری عضلات، چابکی و عکس العمل دارد، شناخته می شود؛ از این رو ویژگی های ترکیب بدنی و آنترپومتریکی نقش مهمی در عملکرد ورزشی ایفا می کنند. هدف از تحقیق حاضر بررسی ارتباط میان شاخص های آنترپومتریکی و ترکیب بدنی با توان انفجاری پایین تنه در والیبالیست های بزرگسال دختر بود. روش شناسی: پژوهش حاضر از نوع همبستگی بود که در آن ۱۶ دختر والیبالیست نیمه حرفه ای با میانگین سنی 20.1 ± 4.34 و شاخص توده بدنی 22.09 ± 3.42 به صورت داوطلبانه شرکت کردند. تمامی والیبالیست ها سابقه ی حضور در لیگ والیبال استان تهران را داشتند. ابتدا اطلاعات آزمودنی ها توسط پرسشنامه ی دموگرافیک جمع آوری و ثبت گردید. سپس ترکیب بدنی (درصد چربی، توده عضلانی، چربی احشایی) آزمودنی ها در شرایط ۳ ساعت ناشتایی توسط دستگاه (OMRON Bf511) اندازه گیری و ثبت شد. در نهایت به منظور ارزیابی توان انفجاری عضلات پایین تنه از آزمون پرش عمودی سارجنت استفاده گردید. یافته ها: به منظور تجزیه تحلیل آماری از ضریب همبستگی پیرسون در سطح معنی داری ($P < 0.05$) استفاده شد. نتایج حاصل از تجزیه و تحلیل آماری بیانگر ارتباط مستقیم و معنی دار توده عضلانی با توان انفجاری پایین تنه ($P < 0.02$) و ارتباط معکوس و معنی دار میان توان انفجاری و درصد چربی بود ($P < 0.05$). همچنین بین قد و توان انفجاری پایین تنه ارتباط مثبت و معنی داری مشاهده شد ($P < 0.05$). نتیجه گیری: نتایج حاصل از این پژوهش نشان میدهد که با افزایش توده عضلانی، توان انفجاری افزایش می یابد، بنابراین توده عضلانی یک فاکتور کلیدی و اثرگذار در رشته والیبال می باشد، از این رو تمرینات مقاومتی به منظور افزایش توده عضلانی به این ورزشکاران توصیه می شود.

کلید واژه ها: توده عضلانی، توان انفجاری، سارجنت، والیبال، درصد چربی

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