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EXPLOSIVE STRENGTH, ARM SWING JUMP CONTRIBUTION AND ECCENTRIC UTILIZATION RATIO IN YOUTH AND JUNIOR FEMALE VOLLEYBALL PLAYERS

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(Original scientific paper)

Fidanka Vasileva[1,2], Andrijana Misovski[3], Josko Milenkoski[3], Georgi Georgiev[3], Aleksandar Aceski[3], Angjel Vasilev[4]

[1]University School of Health and Sport, University of Girona, Girona, Spain
[2]Biomedical Research Institute of Girona Dr. Josep Trueta, Girona, Spain
[3]University Ss. Cyril and Methodius, Faculty of Physical Education, Sport and Health, Skopje, Republic of Macedonia
[4]Elementary School Dimkata Angelov Gaberot -Vatasha, Kavadarci, Republic of Macedonia

Abstract

Vertical jumps are a defying predictor of performance in sports that require explosive action. Objectives of the present study are: 1) to evaluate anthropometric characteristics (height, body mass and BMI), explosive strength (squat jump, countermovement jump and countermovement jump with an arm-swing) and kinematic parameters (the arm swing jump contribution and the eccentric utilization ratio) in female volleyball players; and 2) to compare assessed parameters between youth and junior players. Thirty participants, players that are part of Macedonian Youth (N=15) and Junior (N=15) National Teams, aged 13-18 years, were included in the study. Anthropometric characteristics were measured according to the WorldHealth Organization manual, explosive strength was assessed with the Optojump system, and kinematic parameters were calculated as proposed by Abdel-Rahman (2013). SPSS 23 statistical package was used to perform statistical analysis. Normality of data distribution was tested by K-S test, Skewness and Kurtosis values. Appropriate statistical methods were used to calculate descriptive statistical parameters, and t-test was applied to determine the significance of the difference between youth and junior players. In addition, Cohen's d was applied to calculate the effect size. No statistically significant differences were found between youth and junior players in parameters assessed. Coaches should take in consideration anthropometric and morphological characteristics of the players during the selection process, and work more in a direction of motor abilities development and improvement of technical skills, especially in pioneer and youth categories, instead of putting the main emphasis on player specialization at early age.

Key words: *explosive strength, arm swing jump contribution, eccentric utilization ratio, volleyball players, youth, junior.*

Introduction

Vertical jumps (VJ) are a defying predictor of performance in several sports that require explosive action (Kraska et al., 2009). They are frequent in a game such as volleyball, playing a very important role in various defensive and offensive maneuvers, in both attack and counterattack (Kenny, & Gregory, 2006). Many volleyball actions (e.g., serves, spikes, and blocks) depend on the players' explosive strength, i.e. the ability of players to jump higher (Hale et al., 2019; Rojano-Ortega et al., 2021; Vaverka et al., 2016; Ziv and Lidor, 2010).

VJ are the ''gold standard'' for assessing explosive strength, and they are usually performed as a squat jump (SJ) and a so-called countermovement jump (CMJ). SJ is usually used in sport practice to diagnose muscular strength or explosive strength in primarily concentric muscle actions, and CMJ to measure leg power and explosiveness in more natural stretch-shortening cycle muscle actions (Pupo et al., 2012; Richter et al., 2010).

In a SJ players start from a squatted or semi squatted position without a preparatory countermovement, while in a CMJ, they start from an upright position and initiate a downward movement before starting to move upward (Abdel-Rahman, 2013). It is reported in literature that the CMJ leads to a greater height reach than the SJ because of the stretch-shortening cycle (Komi, 2000). The eccentric-concentric action of a stretch-shortening cycle in a CMJ, contributes to a greater jump height when compared to SJ where no stretch-shortening cycle occurs (Sheppard et al., 2007). More precisely, the muscle while stretching during the eccentric contraction, stores elastic energy that is released in the subsequent concentric muscle contraction (Komi, 2000). The accentuated eccentric load increases the maximum load lifted in the concentric phase of the movement (Doan et al., 2002). Thus, CMJs are generally 2-4 cm higher than SJs, as a result of the stored elastic energy, stretch reflexes, and the active state of the muscles (Fantini et al., 2006).

In addition, kinematic parameters such as the arm swing jump contribution and the eccentric utilization ratio have been shown to increase vertical jump height reach too (Blache & Monteil, 2013; Cheng et al., 2008; Lees et al., 2004; Linthorne, 2001; Policastro et al., 2020; Rojano-Ortega et al., 2021). Moreover, Lees et al. (2004) have reported that the take-off velocity during CMJ can be enhanced by 6–10% or more when using an arm swing, directly affecting the height reach of the jump. The arm swing contributes to a higher velocity at take-off phase, as well as a higher vertical position of the body mass center to be achieved, which increases the vertical jump height reach (Blache & Monteil, 2013). Two theories are explaining the underlying mechanisms of the arm swing effect: the ‘‘pull theory’’ (Lees et al., 2004) and the ‘‘joint torque augmentation’’ theory (Cheng et al., 2008).

Also, an athlete's anthropometric and physical characteristics may represent important prerequisites for success in performing professional volleyball, because morphological predispositions frequently determine a player's functional abilities (Gualdi-Russo, 2001). For instance, height contributes to a greater movement amplitude in attack and block actions, ensuring a better performance of the player (Aouadi et al., 2012; Cabral et al., 2011).

Therefore, objectives of the present study are: 1) to evaluate some anthropometric characteristics (height, body mass and BMI), explosive strength (SJ, CMJ and CMJAS) and kinematic parameters (arm swing jump contribution [ASJC] and the eccentric utilization ratio [EUR]) in female volleyball players; and 2) to compare those parameters between youth and junior players. It was hypothesized that there will be statistically significant difference between youth and junior players in all parameters that were evaluated, since previous work has found differences in regard to these terms according to age and maturational degree (Katic et al., 2006; Papadopoulos et al., 2019; Schneider et al., 2004).

Materials and methods

Participants

The present study is realized on a sample of 30 participants, female volleyball players that are part of Macedonian Youth (N=15) and Junior (N=15) National Teams, aged 13-15, and 16-18 years respectively. Average playing experience of players in Macedonian Youth National Team was 3,94±1,84 years, while for the players of Macedonian Junior National Team was 4,67±2,43 years. According to playing positions, Macedonian Youth National Team was consisted of: 18,75% setters, 12,50% opposite hitters, 31,25% middle blockers, and 37,50% outside hitters, while Macedonian Junior National Team was consisted of: 13,33% setters, 13,33 opposite hitters, 26,67% middle blockers, 13,33% defensive specialists (libero) and 33,33% outside hitters. Players were at the transitioning period of the training season during the evaluation process which took place at the Faculty of Physical Education, Sport and Health in Skopje, Republic of Macedonia. Parents or legal guardians of all participants gave consent for participation before the beginning of the study. The study conformed to the principles outlined in the Declaration of Helsinki.

Instruments

In order to realize the particular aim of the study, measurement of some anthropometric characteristics: height, body mass, and BMI was first performed. Players were measured barefoot and wearing light clothes, according to WHO manual (WHO, 2007).

Height: Measured using a wall mounted stadiometer (SECA SE206).

Body mass: A calibrated digital scale was used (TANITA TBF 300).

BMI: Calculated from height and body mass as follows: $\frac{Body\ mass\ (kg)}{Height\ (m)^2}$ (WHO, 2007)

Before motor abilities assessment, players did the ordinary warm-up protocol that they do at the beginning of each training session during the training process: 2-5 minutes of stretching exercises with the main focus on back and hamstring muscles, 5-7 minutes of easy running (forward and sideways) accompanied with jumping, and 7-10 minutes overall body exercises to mobilize joints and get ready for the testing procedure. Then, explosive strength was assessed with the optical measurement system Optojump, by applying:

- Squat jump (SJ) (Marques, 2017);
- Countermovement jump (CMJ) (Marques, 2017);
- Countermovement jump with arm swing (CMJAS) (Marques, 2017)

Each test was performed thrice and then the best result was recorded. During the testing procedure, players were verbally motivated by the assessors to do their maximal performance. Finally, ASJC and EUR were calculated as proposed by (Abdel-Rahman, 2013):

- ASJC% = $\frac{CMJAS-CMJ}{CMJ}\ x\ 100$
- EUR % = $\frac{CMJAS-SJ}{SJ}\ x\ 100$

Data analysis

Optojump software was used to calculate the height of the performed jump tests, and kinematic parameters (ASJC and EUR) were calculated as proposed by Abdel-Rahman (2013). SPSS 23 statistical package was used to perform statistical analysis. Normality of data distribution was tested by K-S test, Skewness and Kurtosis values. Appropriate statistical methods were used to calculate descriptive statistical parameters, and Student's t-test was applied to determine the significance of the difference between youth and junior players in terms of anthropometric characteristics, explosive strength and kinematic parameters that were assessed. In addition, Cohen's d was applied to calculate the effect size that was interpreted as small ($d \leq 0.20$), medium (d = 0.21 to 0.50), and large effect ($d \geq 0{,}50$) (Lakens, 2013).

Results

According to what is presented in Tables 1 and 2, data of youth and junior players have a normal distribution, with a normal asymmetry considered when values for Skewness are in a range between -1,00 to 1,00 (Zeqiri et al., 2020), and Kurtosis values that are in an acceptable range of -3 to 3 as proposed by Kallner (2013). Except the Skewness value for CMJAS (1,57) in youth players which is above the accepted range, that indicates a right-skewed distribution, meaning that most of the players performed lower in CMJAS than the arithmetic mean value presented. Although, if we take in consideration the value for SD in addition to Skewness value for CMJAS - data seem normally distributed. Based on the values presented for CV%, youth and junior teams are homogenous groups, except that there is a light heterogeneity in terms of explosive strength and kinematic parameters. However, this is considered as acceptable because of the player's specialization in playing positions (Gaurav et al., 2015; Lima et al., 2019).

Table 1. Descriptive statistical parameters of youth players

	N	Min	Max	X	SD	CV%	Skewness	Kurtosis	K-S
Height (cm)	15	168.00	184.00	175.93	4.01	2.28	0.15	0.29	p > .20
Body mass (kg)	15	51.00	77.00	62.03	6.87	11.08	0.42	0.16	p > .20
BMI	15	17.04	24.03	20.01	1.79	8.97	0.52	0.51	p > .20
SJ (cm)	15	14.80	28.50	21.59	3.90	18.05	0.04	-0.50	p > .20
CMJ (cm)	15	16.20	28.10	21.75	3.24	14.89	0.00	-0.20	p > .20
CMJAS (cm)	15	26.40	42.70	30.96	5.11	16.50	1.57	1.73	p > .20
ASJC (%)	15	16.03	92.46	43.96	24.02	54.63	0.83	-0.50	p > .20
EUR (%)	15	13.79	88.11	45.61	22.76	49.91	0.46	-0.87	p > .20

Table 2. Descriptive statistical parameters of junior players

	N	Min	Max	X	SD	CV%	Skewness	Kurtosis	K-S
Height (cm)	15	155.00	185.00	173.47	7.08	4.08	-0.69	2.18	p > .20
Body mass (kg)	15	48.00	69.00	59.03	5.25	8.90	-0.08	0.28	p > .20
BMI	15	18.21	21.63	19.60	1.09	5.54	0.46	-0.84	p > .20
SJ (cm)	15	14.30	33.30	22.87	5.67	24.80	0.09	-0.72	p > .20
CMJ (cm)	15	15.30	35.00	23.29	5.72	24.55	0.61	-0.29	p > .20
CMJAS (cm)	15	25.50	42.00	31.40	4.76	15.16	1.00	0.32	p > .20
ASJC (%)	15	-3.47	117.53	41.26	34.78	84.31	1.00	0.08	p > .20
EUR (%)	15	6.05	120.39	45.45	41.07	90.35	0.94	-0.76	p > .20

Based on data presented in Table 3, and Figures 1 and 2, there is no statistically significant difference between youth and junior players in regard to anthropometric characteristics (height, body mass, and BMI), explosive strength (SJ, CMJ, and CMJAS) and kinematic parameters (ASJC and EUR).

Table 3. Mean average, significance level and effect size of youth and junior players

	Mean Average		p level (t test)	Effect size (Cohen's d)
	Youth	Junior		
Height (cm)	175.93	173.47	0.27	0.44
Body mass (kg)	62.03	59.03	0.20	0.49
BMI	20.01	19.60	0.46	0.28
SJ (cm)	21.59	22.87	0.49	0.27
CMJ (cm)	21.75	23.29	0.39	0.34
CMJAS (cm)	30.96	31.40	0.81	0.09
ASJC (%)	43.96	41.26	0.81	0.09
EUR (%)	45.61	45.45	0.99	0.00

Figure 1. Height (cm), body mass (kg) and BMI in youth and junior players

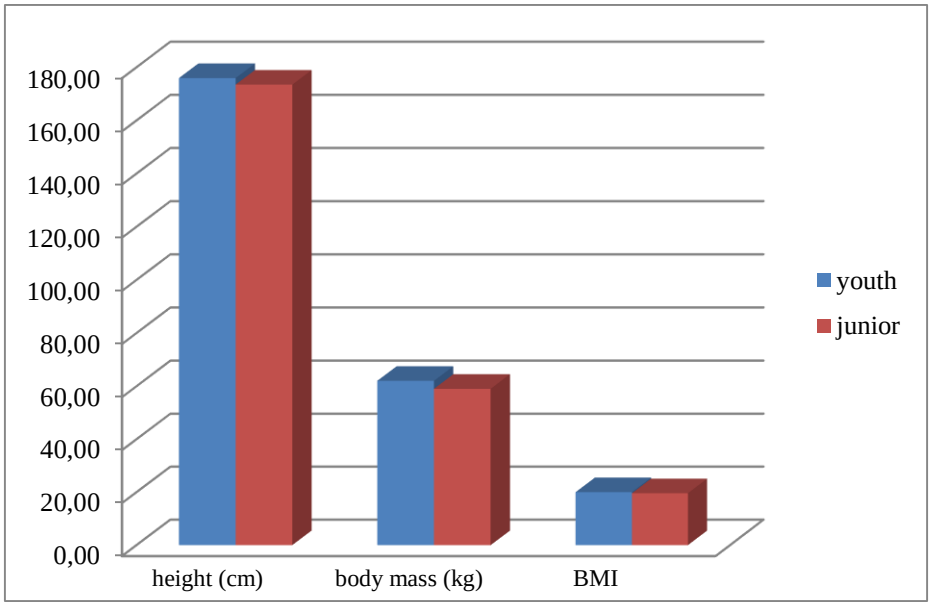
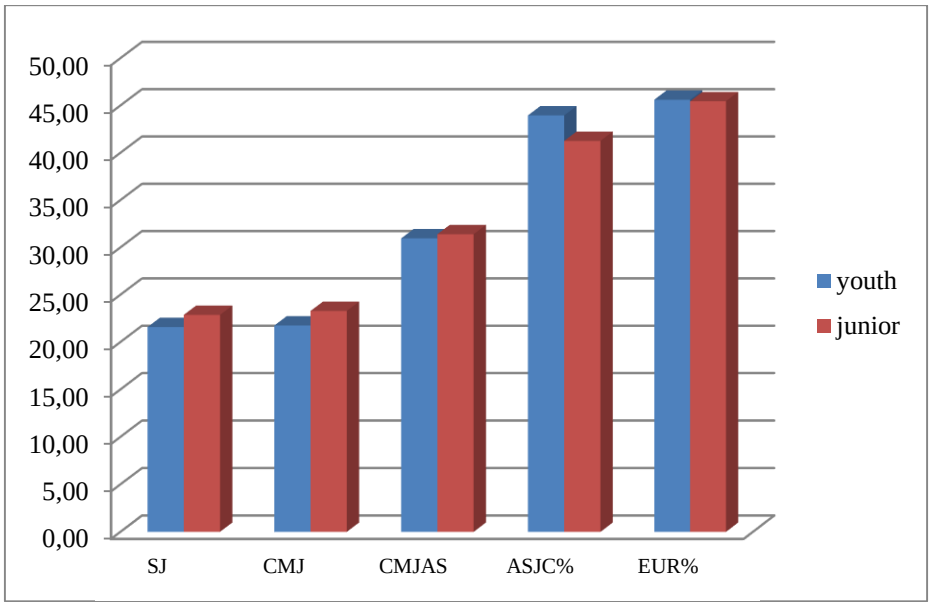


Figure 2. Explosive strength, ASJC% and EUR% in youth and junior players



Discussion

No statistically significant differences were found in terms of anthropometric characteristics, explosive strength and kinematic parameters that were evaluated, between youth and junior players. With regard to the role of biological and chronological age, the findings in literature indicate that height, body mass, and muscle strength increase with age, whereas BMI do not (Papadopoulou et al., 2019). And muscular strength is the ability to generate the maximal amount of force when performing a particular exercise (American Council on Exercise, 2014), while explosive strength is a factor of strength, defined as an ability to generate maximal force in a short time (Singh et al., 2017). Also Schneider et al. (2004) found statistically significant differences in muscular strength for all age groups tested for both genders. This indicates that the maturational degree, strongly influences the muscular strength (Schneider et al., 2004),

Therefore, we advise coaches to put a bigger focus on motor abilities development, such as muscular strength, especially explosive strength, because it is directly related to vertical jump reach (Marques et al. 2009). And players' maximal reach ability in running jumps in attacks, and in standing jumps in blocks, is decisive for their effective actions and the match outcome (Katic et al., 2006; Ziv et Lidor, 2010).

However, psychological conditions and morphological structure of players also affect success in performing professional volleyball, and frequently determine players' functional abilities (Gualdi-Russo, 2001). Gaurav et al. (2015) have reported that anthropometric characteristics of the players influence the level of performance and the final match outcome. In contemporary volleyball, players should have highly developed defensive and offensive skills, as well as great agility, reaction time and explosive strength, that are all allied to height (Petroski et al., 2013). In addition, an anthropometric characteristic such as height, contributes to a greater movement amplitude in attack and block actions during a volleyball game, and ensures a better performance for the team (Aouadi et al., 2012; Cabral et al., 2011). Thus, coaches should take in consideration anthropometric or morphological characteristics of their players during the selection process, in order to achieve a more effective distribution of the available resources in the team.

The higher the training experience and competitive level of the players are – the higher the technical skills, the quality and the efficiency of the player should be (Katic et al., 2006). And a better spiking technique leads to a bigger arm swing jump contribution and a bigger ratio of eccentric utilization, contributing to a greater jump reach and a better outcome of the match (Katic et al., 2006; McGuigan et al., 2006). Underlying mechanisms explaining this effect are: the energetic contribution of the swing, and the greater work of the hip extensor muscles (Blache & Monteil, 2013). Also, the slower shortening velocity of the hamstrings and the gluteus, enable muscles to produce force at a more favorable part of the force-velocity relationship, again contributing to a greater jump reach (Blache & Monteil, 2013). Since the match outcome depends on a variety of specific elements, as well as the final score depends on the quality of attacks, blocks, serves, and the number of the opponent's errors, players must be prepared to perform technical and tactical elements perfectly (Hughes & Daniel, 2003; Marcelino et al., 2008; Marcelino &

Mesquita, 2006). Thus, volleyball coaches should estimate technical skills of the players during the season, and then adjust the training cycle of the team focusing on the improvement of technical skills that significantly determine players' scoring abilities (Miskin et al., 2010).

Taking everything into account, the postulated hypothesis was not confirmed because there were no statistically significant differences in anthropometric characteristics, explosive strength and kinematic parameters that were evaluated between youth and junior players. This outcome indicates that coaches during the training process have probably focused more on player specialization, instead of motor abilities development and technical skills improvement in the players.

Conclusion

No statistically significant differences were found in anthropometric characteristics (height, body mass and BMI), explosive strength (SJ, CMJ and CMJAS) and kinematic parameters (ASJC and EUR) between youth and junior players. Thus, the advice for coaches would be to take in consideration morphological and anthropometric characteristics of their players during the selection process, and to work more in a direction of motor abilities development and improvement of technical skills, especially in pioneer and youth categories, instead of putting the main emphasis on player specialization at early age. Further studies should be planned and designed in the future in order to assess and properly monitor the training process, as well as to provide the adequate improvement of player's performance.

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Conflict of interest

Author declares no potential conflict of interest.

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