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SELECTED ANTHROPOMETRIC CHARACTERISTICS AND BODY COMPOSITION OF FEMALE VOLLEYBALL PLAYERS IN CADET, JUNIOR AND SENIOR NATIONAL TEAMS OF SLOVENIA

NEKATERE ANTROPOMETRIČNE ZNAČILNOSTI IN SESTAVA TELESA PRI ODBOJKARICAH V KADETSKI, MLADINSKI IN ČLANSKI REPREZENTANCI SLOVENIJE

ABSTRACT

Certain morphological characteristics and motor abilities are systematically monitored in Slovenian volleyball teams of different age categories. The study aimed to determine selected anthropometric dimensions and the body composition of 46 members of the cadet, junior and senior women's volleyball national teams. Anthropometric characteristics were measured using the NX-16 $[TC]^2$ 3D-technology for body scanning. Body height was measured using an anthropometer, body mass was weighed using scales, and the body mass index (BMI) was calculated. By using an electrical bioimpedance (EBI) Inbody 720 tetrapolar, 8-point electrode system (Biospace Co., Ltd.), we established percentages of skeletal muscle mass and fat mass as well as body water percentage. The differences among the results for female volleyball players of various categories in terms of body height and body mass are small. Likewise, the body composition results are similar in all three age categories. We also investigated whether the results of anthropometric variables of the upper body differ statistically significantly among individual categories. We identified statistically significant differences between cadet women and senior women in terms of right forearm circumference ($p = 0.04$). Cadet women (24,62 cm) have a smaller forearm circumference than senior women (25,08 cm). Statistically significant differences were also established between cadet women and junior women in terms of right upper arm circumference ($p = 0.03$). Junior women have a statistically significantly larger left upper arm circumference. No statistical significance was recorded with respect to other variables. The results obtained are generally similar to those from studies by other authors.

Keywords: volleyball, women, morphological status

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IZVLEČEK

V slovenskih odbojkarskih reprezentancah različnih starostnih kategorij se sistematično spremlja nekatere morfološke značilnosti in gibalne sposobnosti. Namen raziskave je bil, ugotoviti raven izbranih antropometričnih razsežnosti in sestave telesa 46 reprezentantk v kadetski, mladinski in članskih kategoriji v odbojki. Za merjenje antropometričnih značilnosti smo uporabili tehnologijo NX-16 $[TC]^2$ 3D za skeniranje telesa. Telesno višino smo izmerili z antropometrom, s tehtnico pa telesno maso in izračunali indeks telesne mase. Z uporabo elektro bioimpendančno napravo (EBI) Inbody 720 tetrapolarni 8-točkovni elektrodni sistem (Biospace CO., Ltd.) smo ugotavljali delež skeletne mišične in maščobne mase ter delež vode v telesu. Razlike med rezultati odbojkaric različnih kategorij v telesni višini in masi so majhne. Prav tako so si, v vseh treh starostnih kategorijah, podobni rezultati sestave telesa. Ugotavljali smo tudi ali se rezultati antropometričnih spremenljivk zgornjega dela telesa med posameznimi kategorijami statistično značilno razlikujejo. Ugotovili smo, da med kadetinjami in članicami prihaja do statistično značilnih razlik v obsegu desne podlahti ($p = 0,04$). Kadetinje (24,62 cm) imajo manjši obseg podlahti kot članice (25,08 cm). Do statistično značilnih razlik prihaja tudi pri obsegu leve nadlahti ($p = 0,03$) med kadetinjami (29,93 cm) in mladinkami (31,54 cm). Mladinke imajo značilno večji obseg leve nadlahti. Pri ostalih spremenljivkah se statistična značilnost ne pojavlja.

Ključne besede: odbojka, ženske, morfološki status

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https://doi.org/10.52165/kinsi.28.3.166-186

INTRODUCTION

Volleyball is a team sport game which, in terms of movement structure, belongs to polystructural acyclic sports. The modern volleyball game, both men and women's, has three main characteristics: body height in relation to spike and block reach height, speed of offensive actions, and playing experience (Pušnik, 2007). The game entails different technical elements (serve, receiving the serve, setting, spiking, block and defence) performed in two playing complexes (K1: serve by the opposing team; K2: serve by the home team). High-intensity exercise (active phase of the game) and low-intensity periods (passive phase) are alternated during the game. The game includes different complex movements in various directions: block and spike jumps, serve and setting jumps, fast movements in the field with changes of direction, falls etc. In order to safely and effectively perform such movements, players should have optimal physical fitness and appropriate physical predispositions (Ayuso, Calleja-Gonzalez, Clemente-Suarez & Zourdos, 2015). Like in other ball sports, volleyball is characterised by high specialisation in playing positions due to the player selection process: setter, outside spiker-receiver, middle blocker, opposite and libero. They differ in terms of their morphological characteristics, functional abilities, motor abilities as well as their technical and tactical skills. It is therefore important to know which characteristics, abilities and knowledge are needed for each playing position and to what extent they influence playing performance.

One of the widely researched areas of volleyball includes body composition (body fat percentage, muscle mass percentage, body water percentage etc.) and anthropometric characteristics (body height, body mass, body mass index, longitudinal dimensions, circumferences etc.). Research shows that male and female volleyball players statistically significantly differ in terms of body height and body mass given their playing position (Marques, Van den Tillaar, Gabbett, Reis & Gonzalez-Badillo, 2009; Abazi, Milenković, Telai & Živković, 2017). The reason for these differences lies in the various technical and tactical tasks of a player in a specific playing position (Duncan, Woodfield & al-Nakeeb, 2005). The profile of a modern volleyball player includes sufficient height and appropriate longitudinal dimensions. Unfortunately, the latter are highly genetically determined (Gaurav & Singh, 2014). If the setter touches the ball at a higher point, the path of its flight towards the outside spiker is shortened. The opposing middle blockers thereby have less time to prepare an adequate technical and tactical block. Abazi, Milenkovič, Telai and Živković (2017) found that the setter's and libero's body height is lower than others in the team. Moreover, in modern volleyball, serves are almost exclusively performed in the air as part of a jump. The hight of the

hand's contact with the ball and the distance between this point and the net are the key factors that reduce the time of the ball's flight to the receiver. The short period available to the receiver again influences the adequacy of the positioning and the accuracy of the setting. Based on available research, middle blockers who, as a rule, are the tallest and heaviest players in the team, are also slower at moving around (Sheppard & Borgeaud, 2008; Sheppard et al., 2009). Given the requirements of elite volleyball, the abovementioned authors recommend that, despite this finding, coaches select taller players who are capable of developing greater speed. Namely, rapid side movement along the net is important (Trajković, Milanović, Sporiš & Radisavljević, 2011). The libero does not play at the net and are thus the smallest player in the team (Vujmilović & Karalić, 2014). Their task is to receive the serve and play in defence. An advantage in both of these actions is being smaller. If players have long arms, their reach is better and they can reach even for more distant balls. A libero also has more muscle mass than a middle blocker (Abazi, Milenkovič, Telai & Živković, 2017). The efficiency of outside spikers (outside spiker-receiver and opposite) have an advantage in spiking over the opposing middle blockers if their spike reach is greater. Therefore, in volleyball, longitudinal dimensions play an important role in playing situations. These findings apply to both male and female volleyball players. It often occurs in younger categories that height is not crucial and can be compensated for by fighting spirit, good team interaction, speed of actions, fewer own mistakes etc. Players with less expressed longitudinal measures but above-average motor abilities can also be successful (Zadražnik, 1998).

Morrow, Hosler and Nelson (1980) compared female volleyball players with non-athletes and basketball players, and established that volleyball players have shorter arms, with similar body height and body mass, than basketball players. Compared to non-athletes, volleyball players were taller, heavier and had a lower body fat percentage. Research conducted among Greek 1st league female volleyball, basketball and handball players showed that the volleyball players were taller than their basketball and handball counterparts. Volleyball players were heavier as well but had a higher lean body mass percentage and lower body fat percentage than handball players (Bayios, Bergeles, Apostolidis, Noutsos & Koskolou, 2006). Some other studies reported similar findings (Vujmilović, 2013; Blašković, 1979; Strahonja & Matković, 1983; Strahonja, 1978; Bayios, Bergeles, Apostolidis, Noutsos & Koskolou, 2006). However, results-based performance in volleyball also depends on the correlation between body height and appropriate body composition (Santos et al., 2014). Owing to the above, in many sports, including volleyball, a great deal of attention is focused on monitoring and studying the

morphological status of active athletes and those aspiring to become one (Ackland et al., 2012; Dopsaj et al., 2017). Besides physical fitness, an athlete's body composition is a good indicator of their health (Aytek, 2007). Practically all movement components are related to body fat percentage: agility, strength, speed, flexibility, and explosive power. Low body fat percentage is generally strongly preferred in sports that include extensive running or jumping. Nevertheless, body fat is important for some physiological and metabolic functions of the body. Women require a slightly higher percentage of body fat than men for their body to function properly. The negative impact of excessive body mass percentage on the expression of motor abilities was reported by Strahonja (from Zadražnik, 1998): "Subcutaneous fat in this task is again a factor that negatively affects the explosive power of the arms and legs and thereby adversely impacts the performance of technical elements that are executed in a jump." Excess fat acts like 'dead weight' in activities where mass needs to be lifted several times to counter gravity while moving around and jumping. Excess body fat reduces the efficiency of movement and increases energy needs. On the contrary, a lean body mass contributes to the development of power in high-intensity activities and ensures greater absolute power for resilience to high static and dynamic loading (Mala et al., 2015). An important role is played by body water percentage as well.

In volleyball, competitive categories are divided into several levels. In Slovenia, the categories include, in the following order: up to 10 years of age, children play a modified version of volleyball named mini volleyball; the same applies for children up to 12 years – they play a modified version, i.e. small volleyball; the category of boys and girls (up to 14 years) play on a normal-size court with a slightly lower net height; male and female cadets (up to 16 years) as well as junior men and women (up to 18 years) play volleyball according to the official rules. The last category is absolute – senior men/women. Janković, Đurković and Rešetar (2009) emphasise that the volleyball cadet category is particularly interesting when it comes to investigating the anthropometric characteristics of male and female players because in this age period the universal model transitions into the specialisation of players for given playing positions. Moreover, the impact of puberty on the above-mentioned characteristics should not be overlooked. Using a sample of 139 matches, Davila-Romero, Garcia-Hermoso and Saavedra (2012) found that an effective service and attack are very important for a good result in the women's cadet category. Both technical elements depend on reach height, which is also influenced by players' body height. Monitoring the development of anthropometric characteristics and body composition through three age categories is also important as it allows

us to establish, using a model of elite female senior category players, what their model characteristics in the cadet category were and which characteristics are relevant for which playing role. Namely, in this way we were able to verify the adequacy of the selection criteria for guiding players towards individual playing positions. This objective can be added to the goals we seek to achieve with this study.

At the Faculty of Sport in Ljubljana, the Volleyball Federation of Slovenia regularly organises measurements of male and female national team players of different age categories. The purpose of these measurements is to monitor the development of high-quality male and female players, who are then directed, also based on these measurements, into individual national-team selections. The many years of such measurements have led to an extensive database being produced of the morphological characteristics and motor abilities of both male and female players. We decided to determine some anthropometric dimensions and body composition in the categories of cadet women, junior women and senior women. We were interested in whether Slovenian female volleyball players differ from their international rivals in terms of these parameters. The findings will be important in the future while formulating guidelines for the selection process. We also aimed to establish whether female players of individual categories statistically significantly differ among themselves in selected characteristics, and, if so, which ones. Due to the small number of players, we decided not to identify differences between individual playing positions. In each category, each team had only two setters, two liberos and two opposites. The number of middle blockers and outside spikers-receivers was slightly higher (3–4 players). Such a comparison would be of particular interest for sport science.

METHODS

Participants

The study included 46 subjects:

- cadet women's national team (up to 16 years): 15 players (14.8 ± 0.42)
- junior women's national team (up to 18 years): 14 players (17.75 ± 0.42)
- senior women's national team (above 18 years): 17 players (19.58 ± 1.47)

Accessories

- GPM anthropometer (Switzerland)
- NX-16 3D-body scanner ([TC]^2, Cary, North Carolina, USA)
- InBody 720 Tetrapolar 8-Point Tactile Electrode System (Biospace Co., Ltd.)
- 3D Body Measurement System, Version 7.4.1, software for Windows

Variables

- body height
- body mass
- body mass index
- skeletal muscle mass
- fat mass percentage
- body water percentage
- lean mass of arms
- lean mass of legs
- right arm length
- left arm length
- right upper arm circumference
- left upper arm circumference
- right forearm circumference
- left forearm circumference
- right wrist circumference
- left wrist circumference
- right leg length
- left leg length

- right thigh length
- left thigh length
- right thigh circumference
- left thigh circumference
- right knee joint height
- left knee joint height
- right knee joint circumference
- left knee joint circumference
- right calf circumference
- left calf circumference
- right calf height

Procedure

The measurements were performed in the Faculty of Sport's physiology laboratory between 2015 and 2018. At the time of the measurements, appropriate conditions for an accurate measurement process were ensured.

Body height was measured using the GPM anthropometer (Switzerland). The standard measurement position required bare feet, double-leg stance, upright posture and looking straight ahead. The measurer, while standing on one side of the subject, positioned the anthropometer perpendicular to the ground and directly behind the subject.

Body composition was measured using an electrical bioimpedance (EBI) Inbody 720 tetrapolar, 8-point electrode system (Biospace CO., Ltd.). The mentioned system enables a direct segmental multi-frequency electrical-bioimpedance analysis. The subjects underwent measurements in their underwear, with bare feet and without any jewellery.

The NX-16 3D-body scanner ($[TC]^2$, Cary, North Carolina) was used to measure anthropometric characteristics of subjects, noting that it enables the faster, more accurate and contactless measurement of body characteristics. The subjects removed their jewellery and clothes. They entered the device in their light-coloured, close-fitting underwear with bare feet.

They assumed a natural posture (straight back, relaxed shoulders, arms extended in the elbows, chin slightly lifted). They positioned their feet on the marked spaces and held the scanner handle in their hand. They had to stand still as much as possible during the measurement. We gathered data by using the multi-scan option where the scanner performs three consecutive body scans and then calculates the mean values.

Statistical analysis

Data were processed using the Microsoft Excel software (version 2011, Microsoft Corporation, Redmond, USA). Statistical processing was performed using the SPSS software for Windows (version 25.0, SPSS Inc., Chicago, USA). The results were processed using descriptive statistics. The equality and/or inequality of variances was verified using Levene's test of homogeneity of variance. In some variables, variances were unequal, which is why, to allow for better adjustment of results, we applied the Games-Howell post hoc test that compares individual categories.

Data were processed using the Microsoft Excel software (version 2011, Microsoft Corporation, Redmond, USA) and asymmetry percentage was calculated.

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RESULTS

Body composition of female volleyball players

Given the importance of body height and the related other dimensions that are key to successful volleyball playing (block reach, spike reach, reach in defence etc.), we first present the results for these variables. The result for body mass does not tell much in itself and is less appropriate for comparing results. Tables 1, 2 and 3 show arithmetic means, minimum and maximum results in an individual category for the most informative variables: body height and mass, body mass index, fat and muscle mass percentages as well as body water percentage.

Table 1. Basic characteristics of cadet women.

	BH	BM	BMI	%BF	%SMM	%BW
M	175.10	66.63	21.62	12.51	30.03	39.37
MAX	186.50	77.00	25.10	19.80	35.40	46.10
MIN	164.00	54.20	18.40	5.00	25.60	34.00
SD	7.38	7.59	2.14	4.05	3.29	4.08

Legend: M – mean; MAX – maximum result; MIN – minimum result; SD – standard deviation; BH – body height; BM – body mass; BMI – body mass index; %SMM – skeletal muscle mass percentage; %BF – body fat percentage; %BW – body water percentage

Table 2. Basic characteristics of junior women.

	BH	BM	BMI	%BF	%SMM	%BW
M	179.88	73.43	22.64	14.91	32.90	42.82
MAX	192.40	90.30	26.80	25.20	41.40	53.80
MIN	163.50	58.30	17.80	7.20	27.90	36.90
SD	8.14	10.80	2.63	5.58	4.12	5.22

Legend: M – mean; MAX – maximum result; MIN – minimum result; SD – standard deviation; BH – body height; BM – body mass; BMI – body mass index; %SMM – skeletal muscle mass percentage; %BF – body fat percentage; %BW – body water percentage

Table 3. Basic characteristics of senior women.

	BH	BM	BMI	%BF	%SMM	%BW
M	180.05	72.35	22.33	14.85	31.96	42.11
MAX	188.00	81.70	26.20	22.30	36.33	47.10
MIN	164.10	62.60	19.60	9.70	26.63	35.30
SD	7.01	6.20	1.76	3.59	2.97	3.66

Legend: M – mean; MAX – maximum result; MIN – minimum result; SD – standard deviation; BH – body height; BM – body mass; BMI – body mass index; %SMM – skeletal muscle mass percentage; %BF – body fat percentage; %BW – body water percentage

The results for the players' anthropometric variables by individual category are presented in Tables 4, 5 and 6.

Table 4. Anthropometric values of variables of junior women.

VARIABLE	M	MAX	MIN	SD
right arm length	58.62	62.50	51.90	3.44
left arm length	57.87	61.50	52.10	3.17
right upper arm circumference	31.76	36.40	27.00	2.91
left upper arm circumference	31.54	35.70	27.20	2.65
right elbow joint circumference	24.77	27.60	23.10	1.49
left elbow joint circumference	24.80	28.00	22.50	1.65
right forearm circumference	24.94	27.30	22.70	1.37
left forearm circumference	25.02	27.60	22.90	1.39
right wrist circumference	16.04	18.00	14.80	0.99
left wrist circumference	16.53	17.70	14.90	0.99
right leg length	109.76	117.70	96.00	6.92
left leg length	109.71	117.20	96.00	6.86
right thigh length	39.67	81.60	30.60	15.53
left thigh length	39.63	81.60	30.70	15.57
right thigh circumference	64.49	77.70	54.70	6.83
left thigh circumference	64.04	77.10	53.90	6.88
right knee joint height	49.78	53.30	44.20	2.93
left knee joint height	49.79	53.30	44.20	2.93
right knee joint circumference	39.04	43.10	32.70	3.22
left knee joint circumference	38.54	42.70	32.70	3.11
right calf circumference	38.58	43.50	34.40	2.72
left calf circumference	38.36	42.50	34.30	2.60
right calf height	36.23	39.70	29.90	3.20
left calf height	36.32	42.90	30.20	3.65

Legend: M – mean; MAX – maximum result; MIN – minimum result; SD – standard deviation

Table 5. Anthropometric values of left and right upper and lower extremities of cadet women.

VARIABLE	M	MAX	MIN	SD
right arm length	57.29	60.60	53.40	2.26
left arm length	56.15	59.90	52.90	2.09
right upper arm circumference	30.24	33.80	26.10	2.26
left upper arm circumference	29.93	32.20	26.50	1.69
right elbow joint circumference	24.19	26.20	22.40	1.29
left elbow joint circumference	23.97	25.60	22.40	1.16
right forearm circumference	24.62	26.40	22.10	1.30
left forearm circumference	24.37	26.50	21.90	1.45
right wrist circumference	16.01	17.00	14.90	0.64
left wrist circumference	16.50	17.50	15.50	0.64
right leg length	106.25	118.60	98.70	6.05
left leg length	106.12	118.60	98.60	6.02
right thigh length	33.79	40.30	25.80	3.93
left thigh length	33.73	40.20	25.50	3.99
right thigh circumference	60.36	67.50	54.10	4.38
left thigh circumference	60.61	68.70	53.60	4.63
right knee joint height	50.60	65.70	45.80	6.33
left knee joint height	50.64	65.70	45.80	6.32
right knee joint circumference	39.39	54.30	34.80	5.53
left knee joint circumference	39.27	53.10	35.00	5.15
right calf circumference	37.93	48.70	33.80	4.28
left calf circumference	37.79	46.90	33.50	3.85
right calf height	38.21	59.70	31.70	9.01
left calf height	38.36	59.70	32.70	8.89

Legend: M – mean; MAX – maximum result; MIN – minimum result; SD – standard deviation

Table 6. Anthropometric values of left and right upper and lower extremities of senior women.

VARIABLE	M	MAX	MIN	SD
right arm length	59.13	64.60	54.00	3.29
left arm length	58.78	64.60	54.10	2.92
right upper arm circumference	31.15	34.10	27.50	1.98
left upper arm circumference	31.03	33.10	27.50	1.90
right elbow joint circumference	25.08	27.20	22.80	1.41
left elbow joint circumference	24.99	28.00	22.10	1.52
right forearm circumference	25.50	26.80	23.30	1.12
left forearm circumference	25.08	26.80	22.80	1.22
right wrist circumference	16.20	17.60	14.00	0.99
left wrist circumference	16.79	17.60	15.80	0.52
right leg length	108.66	114.30	99.90	4.29
left leg length	108.60	114.00	99.70	4.26
right thigh length	39.35	84.90	32.30	15.33
left thigh length	39.31	84.90	32.70	15.35
right thigh circumference	63.48	74.50	58.60	4.63
left thigh circumference	62.61	74.00	57.60	4.61
right knee joint height	50.17	52.70	45.50	2.29
left knee joint height	50.19	52.70	45.50	2.30
right knee joint circumference	38.56	42.30	34.40	2.31
left knee joint circumference	38.26	42.70	34.20	2.23
right calf circumference	37.72	41.00	35.30	1.83
left calf circumference	37.72	41.00	34.90	1.85
right calf height	36.98	40.00	32.50	2.34
left calf height	36.62	38.80	33.50	1.79

Legend: M – mean; MAX – maximum result; MIN – minimum result; SD – standard deviation

Table 7. Comparison of anthropometric characteristics of the upper body by individual categories.

VARIABLE	COMPARED CATEGORIES	MEAN VALUE OF DIFFERENCES	p
right arm length	junior – senior	0.51	0.62
	cadet – senior	1.84	0.07
	cadet – junior	1.33	0.21
left arm length	junior – senior	-2.32	0.43
	cadet – senior	-0.61	0.84
	cadet – junior	1.72	0.57
right upper arm circumference	junior – senior	-0.62	0.43
	cadet – senior	0.91	0.24
	cadet – junior	1.52	0.06
left upper arm circumference	junior – senior	-0.51	0.47
	cadet – senior	1.10	0.12
	cadet – junior	1.61	**0.03**
right forearm circumference	junior – senior	0.56	0.18
	cadet – senior	0.88	**0.04**
	cadet – junior	0.32	0.45
left forearm circumference	junior – senior	0.06	0.89
	cadet – senior	0.72	0.11
	cadet – junior	0.65	0.16
right wrist circumference	junior – senior	0.16	0.58
	cadet – senior	0.19	0.51
	cadet – junior	0.03	0.92

Legend: p – statistical significance

Table 7 presents values processed using the Games-Howell post hoc test that relies on the assumption of variance inequality. Variance equality and/or inequality was verified using Levene's test of homogeneity of variance. As the variances of the selected variables were unequal, we adjusted the results accordingly using the Games-Howell post hoc test that is used to compare individual categories.

DISCUSSION

Our study aimed to establish similarities/differences in the selected anthropometric measures and body composition in the categories of cadet women, junior women and senior women. The finding that the results for individual player categories are quite similar is somewhat surprising. Still, it should be noted that it is a specific feature of Slovenian volleyball to have players who are relatively young (up to 26 years) in the national women's volleyball team. At this age, many

promising and also high-quality players usually finish their competitive career. Therefore, young players frequently join the senior women's national team to rejuvenate it. As stated in the description of the sample of women's national team members, the average age is about 19.5 years (19.58 ± 1.47). Noting the above, large differences were not expected in the results for both young categories and those for senior women.

The average height of senior women was 180.05 cm, junior women 179.88 and cadet women 175.1 cm. Kosmač (2007) studied the anthropometric characteristics of Slovenian volleyball players holding different playing positions in the 1st Slovenian Volleyball League. Setters were 175.1 cm tall on average, middle blockers (the tallest players in the sample) 181.1 cm, opposites and outside spikers-receivers 178.8 and 177.4 cm, respectively. Players in the libero position were the shortest (169 cm). Bojanić, Ljubojević, Krivokapić, Nokić and Mekić (2022) determined the body height of the junior women's national team of Montenegro at 179.5 ± 4.7 cm and of Kosovo 175.2 ± 7.43 cm. Due to their specific playing tasks (receiving the serve and playing in defence), the player holding the position of libero does not need to be very tall. If the libero is excluded from the list and average body height is then calculated, the senior women's national team players measure 181.5 cm. We believe that this is more correct data as regards the calculation of body height. The tallest national team player measures 192.4 cm and plays in the position of opposite. She is a player who, besides fast spiking, tackles situations when the ball is passed in a high arch and the opponent performs a double or even triple block. In such situations, spike reach height is a clear advantage. Female volleyball players in the junior and senior categories have very similar results, while those of the cadets are slightly different. The body height of Slovenian female volleyball players is similar to respective results in other studies. The average height of Cuban women's national team players who competed at the Olympics in 1992, 1996 and 2000 was 181.6 cm (Carvajal et al., 2012). Greek female volleyball players who play for the first (N = 79) and second (N = 84) national leagues were 177.1 ± 6.5 cm tall on average. The first-league players (179.6 ± 5.8 cm) were on average 4.9 cm taller than their second-league counterparts (174.7 ± 6.2 cm) (Bayios, Bergeles, Apostolidis, Noutsos & Koskolou, 2006). A study of Brazilian female volleyball players (aged up to 17 years) established they were 181.6 ± 6.1 cm tall on average (Cabral, Cabral, Miranda, Dantas & Reis, 2011). In a 2013 study, Afonso, Medeiros, Joao and Nikoladis examined the height of female volleyball players who had competed in the World Grand Prix of the International Volleyball Federation (FIVB) between 2004 and 2012. The sample included as many as 2,074 players. Their average height was 182.5 ± 7.6 cm (the shortest and tallest player measuring 155 and 204

cm, respectively). In his study, Aytek (2007) reported the heights of senior women's volleyball national team members. The average body height of the Brazilians was 183.41 cm, the Chinese 185.66 and the Russians 189.33 cm.

The body mass index (BMI) was also calculated. A comparison of players based on the body mass index is more correct. The average body mass index (BMI) of all female volleyball players in the sample is 22.19. The lowest BMI is that of cadet women (21.62), the highest of senior women (22.33), whereas junior women's national team members' BMI is 22.64. In his study of Turkish female volleyball players, Aytek (2007) reported much lower BMIs. The average BMI of cadet women was 19.55, of junior women 19.97 and of senior women 19.93. Bojanić, Ljubojević, Krivokapić, Nokić and Mekić (2022) determined the body mass of Montenegrin junior women at 68.4 ± 4.66 kg and their BMI at 21.29 ± 1.72. Female members of the Kosovo volleyball national team on average weighed 65.0 ± 7.18 kg and their BMI was 21.2 ± 2.21. However, the BMI does not reveal body composition. We thus cannot conclude that Slovenian female volleyball players have higher BMI results due to higher muscle or fat mass. Consequently, we conducted an analysis of body composition that revealed that Slovenian female volleyball players, given their slightly lower fat mass percentage, had a higher muscle mass percentage in terms of the BMI results.

Body composition is an important indicator of an athlete's physical fitness and health. The fat mass percentage of cadet women was 12.51%. A slightly higher figure was recorded with senior women (14.85%) and the highest with junior women (14.91%). Aytek (2007) recommends between 12% and 16% of fat mass for female volleyball players. The sample he examined showed 15.8% of body fat. Similar values were also reported by some other researchers (from Razboršek, 2018): Withers reports 17.0% of fat mass in senior women, Kovalski et al. reports 19.5%, Fleck et al. 11.7%, Tsunawake et al. 18.3%, Minowa et al. 22.4% (±4.7%) and Papadopolou 21.3% (±5.5%). Bojanić, Ljubojević, Krivokapić, Nokić and Mekić (2022) found that the fat mass of Montenegrin junior women was 17.0 ± 2.59%, whereas that of Kosovan female national team members was 22.7 ± 3.71. The results of these studies corroborate the previous finding that Slovenian female volleyball players are not too heavy and have more muscle mass.

Volleyball is not a time-limited sport. A match can even last 2–3 hours. This means that players must be strong, whereas their strength is related with the percentage of water in their body. A decrease in this percentage means a decrease in strength. Owing to this, volleyball players have

a higher body water percentage than normal people. Players with more muscle mass have a higher quantity of water in their bodies given that muscles contain more water compared to fat (Aytek, 2007). In our sample of volleyball players, the body water percentage is 41.4% on average. These figures for cadet women, junior women and senior women are 39.37%, 42.82% and 42.11%, respectively.

The respective figures for the skeletal muscle mass of cadet women, junior women and senior women are 30.03%, 32.90% and 31.96%. Cadet women have the lowest body water percentage. It is similar in the categories of junior women and senior women. However, it should be noted that the range of results for junior women is the biggest. The lowest skeletal muscle mass percentages are quite similar (cadet women: 25.60%; junior women: 27.90%; senior women: 26.36%). The maximum result for skeletal muscle mass among cadet women is 35.40% and among senior women 36.33%. The maximum percentage among junior women is 41.40%. This percentage belongs to a junior player who is 192.4 cm tall (one of the tallest players in the entire sample) and has by far the highest percentages for body water (53.80%) and fat mass (17.0%). Bojanić, Ljubojević, Krivokapić, Nokić and Mekić (2022) determined the muscle mass of Montenegrin junior women at 29.3 ± 2.23% and that of Kosovan female national team members at 27.7 ± 2.61%. These results corroborate the above statement that Slovenian female volleyball players have a higher body mass index due to their bigger share of skeletal muscle.

Models show that anthropometric characteristics are very important for the success of elite volleyball players, both male and female. A volleyball player is mainly distinguished by their longitudinal dimensions because the activities in a volleyball game are closely related to body height as well as arm and leg length. Body height is related to block and arm length, spike to body height and arm length, and defence to arm length. Body height is the most valuable in actions occurring along the net (Ocepek, 2004). Tables 4, 5 and 6 show anthropometric values of measurements of anthropometric variables of the left and right upper and lower extremities. The results of a study of 126 senior women's national team members (Abazi, Milenkovski, Telai & Živković, 2017), 23.3 ± 2.9 years old and 160–187 cm tall, showed the following values: mean value of circumference of upper arm 25.7 ± 2.4 cm, forearm 24.1 ± 1.8 cm, calf 36.1 ± 2.4 cm and thigh 57.4 ± 4.8 cm. The results for members of the Slovenian senior women's national team are slightly higher.

One goal of the task was to establish any statistically significant differences between anthropometric variables of the upper body. In volleyball, the arms are practically moving all

of the time and are importantly involved in the technical implementation of most elements in constantly changing game situations. Most of these techniques are performed using the dominant arm and most female volleyball players are right-handed. Due to this one-sided burdening of the arms, asymmetries in this part of body are common. Namely, this is precisely what Razboršek (2018) established. The results for lean mass of the right and left arms of female volleyball players statistically significantly differed ($p = 0.00$), with the right arm having a higher mass. Likewise, the results regarding the circumference of the left and right forearm statistically significantly differed ($p = 0.02$), with the right forearm having a bigger circumference. Razboršek found no statistically significant differences in the circumference of the left and right upper arm ($p = 0.11$). However, the circumference of the right upper arm was greater than that of the left. Owing to the technical role and frequency of motor tasks of the arms, this segment of the body must be given the appropriate share of high-quality training. For this reason, we expected larger differences in the results of anthropometric variables of the upper extremities at least between the cadet and junior/senior categories. Our expectations also arose from being familiar with the work in Slovenian women's volleyball clubs. Not many clubs, from which national team members come, have a coach for cadet teams who is specialised in physical preparation. This segment is relatively neglected. The technical and tactical preparation of female players of this age is at a very high level of quality, as corroborated by the results of national teams at this age on the European and global levels. The cadet national team currently holds 9th place in the European U16 ranking (www.cev.eu). Players in the junior women category, besides training in that category, often also train in the same environment as the senior club team. Some of them, i.e., the best, actually train only with the latter. Most clubs that have a senior team also have a physical preparation specialist among their team of experts. If the sample of senior women players had been older, we would have expected differences at least in terms of upper arm and forearm circumference given the results for the cadet and junior categories. Since members of the senior women's national team are barely 2 years older on average than members of the junior women's national team, the achieved results are acceptable. Only two variables showed statistically significant differences. Statistically significant differences were observed between cadet women and senior women in the variable of right forearm circumference, at the level of significance $p < 0.05$. Cadet women have a statistically significantly smaller forearm circumference ($p = 0.04$) on average than senior women. Statistically significant differences were also found between cadet women and junior women in terms of circumference of the left upper arm ($p = 0.03$). Junior women have a

statistically significantly larger left upper arm circumference. No statistical significance was recorded with respect to other variables.

The results obtained will also be useful in volleyball practice. In further research, the points raised in the discussion will need to be verified. It must be established whether the asymmetries in Slovenian female volleyball players of different age categories are due to the specific aspects of volleyball play, along with which body segments and which age category. In a larger sample of subjects, it would be interesting to establish whether differences exist in anthropometric variables and body composition between individual playing positions. These results will be particularly welcome for coaches in the process of directing female volleyball players towards individual playing positions.

CONCLUSION

The study is one of the first attempts to establish the anthropometric characteristics and body composition of Slovenian volleyball women's national team members. Due to the small sample of national team members in individual categories, the goals were unfortunately more modest. Over the last 15 years, Slovenian volleyball on the European and international levels has seen tremendous progress and joined the narrow elite. In the last 8 years, the women's national team has achieved the following successes: U23 national team (2017) – 2nd place at the World Championship; since 2015, the women's national team has taken part in the European Senior Championship already three times; the European ranking: U19 – 13th place, U18 – 5th place and U16 – 9th place (www.cev.eu). This means the established characteristics and abilities of female volleyball players may also be interesting for a broader circle of experts who investigate performance factors in volleyball. The sample consisted of high-quality female volleyball players and may be used as a benchmark for assessing the results of comparable studies. The findings reveal small differences in certain anthropometric variables and the body composition of Slovenian female volleyball players of three age categories. The results are within the limits established by some other researchers in their studies. This study is important because it provides benchmark results for future research in this area. Moreover, the results of some anthropometric variables (e.g. longitudinal dimensions) and body composition (e.g. fat mass and muscle mass percentages) will help while guiding female players in volleyball and selecting national team members.

Ethical statement

"We declare that the research reported in the paper was undertaken in compliance with the Helsinki Declaration of 1975, revised in 1983."

Acknowledgment

We thank the players and the staff of the two national teams for their cooperation during this research and related survey.

Declaration of Conflict of Interests

The author declares no conflicts of interest with respect to the research, authorship and/or publication of this article.

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