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Basic Anthropological Characteristics of Elite U17 Youth Serbian Female Volleyball Players According to Playing Position

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Abstract: This study examines the differences in the anthropometric characteristics and motor abilities of young elite female volleyball players depending on their playing position. This study was conducted with 114 U17 female players of the Serbian national team (age: 15.4 ± 0.4 years; body mass: 65.8 ± 7.8 kg; height: 176.8 ± 7.7 cm). All participants had at least four years of volleyball experience. A one-way ANOVA revealed significant differences ($p \leq 0.05$) in body mass (BM), body height (BH), body mass index (BMI), one-arm standing reach (1ARS), two-arm standing reach (2ARS), arm span, a medicine ball throw (MT), standing long jump (SLJ), squat jump (SJ), countermovement jump without an arm swing (CMJ), 5 m sprint (S5), 15 m sprint with a flying start (S15), 20 m sprint (S20), and *t*-test (TT). The results show that a player's position significantly impacts their anthropometric characteristics and motor abilities, with liberos requiring agility and flexibility, while middle blockers and opposite hitters focus on strength and explosiveness. Outside hitters and setters achieved high results in jump tests, while outside hitters, although agile, had slightly lower results in the long jump. The results confirm that BH and BM, 1ARS, 2ARS, arm span, explosive power, agility, speed, and flexibility significantly impact performance, indicating that a player's position affects their anthropometric characteristics and motor abilities.

Keywords: volleyball team; national team; youth athletes and elite performance

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1. Introduction

Volleyball is an Olympic team sport played by two teams of six players who aim to score by grounding the ball in the opponent's court using techniques such as blocking and spiking the ball over a net that divides the two playing areas [1]. Motor skills are a key factor for success in any sport, as they enable an adequate response to the skills and loads imposed by the game itself. Furthermore, team sports like volleyball consist of many different skills that dominate different parts of the game, making it nearly impossible for one player to master all of them. As a result, team sports require team compositions made up of athletes specialized in performing specific roles, defined by player positions. Each position involves specific tasks that require specialized skills to perform efficiently. These abilities are developed through numerous repetitions in game situations and focused training. Research has shown that early specialization contributes to a longer and more successful career [2]. As a complex team sport, volleyball includes various motor skills and can be described as a "poly-structural complex sport", in which players engage in competitive activity [3], with dynamic transitions of actions from one side of the court to the other, all aimed at winning the rally or achieving a specific result. Additionally, these short dynamic periods of play are followed by longer rest periods during which the player has

enough time to recover, making volleyball almost immune to fatigue, and thus one of the most attractive sports. As a modern sport, volleyball requires a high level of general motor skills, specific knowledge of the game, and specialized player positions. Specialization of positions is a crucial process, primarily due to the different demands of game segments, technical and tactical ideas, as well as specific skills and characteristics associated with a particular player position.

Anthropometric characteristics are useful for talent identification, as they vary between different sports, but also depend on the player's position in the team, as well as the specific requirements of that position [4], and such data can also be compared with the anthropometric characteristics of other athletes. Anthropometry has been a highly researched topic in volleyball in recent years, both in general [5–10] and specifically in women's volleyball [11–18], highlighting its significance and the interest it generates in this field. In modern scientific research conducted on young elite subjects [19], the differences in body structure of volleyball players were examined in relation to playing position. Findings indicate that middle blockers and opposite hitters are the tallest (201.57 $\pm$ 4.92 cm; 203.00 $\pm$ 4.41 cm) and heaviest (86.14 $\pm$ 6.79 kg; 91.60 $\pm$ 6.69 kg) players in the team. The libero has the lowest values of body height and body mass. A study by Giannopoulos et al. [20] aimed to examine the relationships between somatotype, competition level, and attacking performance in elite volleyball players. The results show that Greek elite volleyball players in the first rank of the competition have an ectomorph–endomorph somatotype, regardless of their playing position. The second rank of the competition is characterized by a central somatotype in forwards, ectomorphic–endomorphic in middle blockers, and a balanced endomorphic somatotype in opposite hitters. Middle blockers were found to perform better than outside hitters and opposite hitters, regardless of the level of competition. Recommendations are to give special attention to ectomorphic middle blockers for the reason of exhibiting a high level of performance in attack [21] compared national team and Universiade participants to examine differences in physical and physiological characteristics and performance. The results indicate similarities in anthropometric measurements and anaerobic capacity in both teams, while the national team had significantly higher results in maximal oxygen consumption (VO_2max), upper body strength, and jumping ability. In this regard, upper body strength is an important factor in high-level competition, as indicated by the results of this research. Upper body strength in volleyball is essential for successful blocking and hitting, as well as injury prevention due to a high volume of shots during competition or practice.

One study by Mostaert et al. [22] found that anthropometric characteristics, physical performance, and motor coordination can predict selection for national youth volleyball teams. The research showed that selected players were already taller and had better jumping performance at a young age, while females displayed better motor coordination, indicating that the development of these skills can increase the chances of selection for the national team. The study conducted by Tsoukos et al. [23] found that the vertical jump, spike jump reach and medicine ball throw tests can predict player selection with high accuracy. The mechanisms of strength and speed regulation were significant predictors of game performance, while the spike and block techniques were the strongest predictors of game quality across different age groups [24].

Some papers describe a connection between anthropometric characteristics and situational motor abilities, where it is confirmed that there is a difference [25,26]. Numerous studies analyzed and evaluated the correlation between motor and anthropometric characteristics of elite volleyball players according to the roles they played within the team. It was observed that most anthropometric characteristics correlate with each other, especially body height with body mass. Concerning the connection between motor and anthropometric characteristics, they show that all anthropometric variables are positively correlated with the Vertec jump test, while there is a negative correlation with the squat jump; also, the spike jump is positively correlated with height and skin folds [10,27,28].

Studies conducted on young volleyball players, such as those by [29,30], have confirmed significant differences between positions in volleyball, which serve as a direct indicator of the level of difficulty and complexity of the game itself, within the established player positions on the team. Some studies found differences in the situational motor abilities of young volleyball players of different positions [30], and others found differences in elementary technique between volleyball players of different ranks of the competition [31]. Studies dealing with anthropological and motor testing during the selection of junior volleyball teams have found that statistically significant parameters such as BMI (body mass index), SRJ (single-legged repetitive jumps), and CMJ (countermovement jump) successfully distinguish elite volleyball players from others. These results were confirmed in studies dealing with explosive strength assessment of the lower limb muscles, which have been proven to be significant in the correct identification of volleyball talents [32,33].

Previous research suggests that there are studies examining both the correlations and differences between anthropometric characteristics and motor abilities based on playing position. However, none of these studies have investigated the differences in motor abilities and anthropometric characteristics in relation to playing positions among young Serbian female volleyball players. There is a real need to investigate the differences in abilities between player positions, with the aim of timely specialization. Serbian female volleyball players have achieved significant success in international competitions, as evidenced by numerous medals from World and European Championships, as well as the Olympic Games. Additionally, the country has won multiple titles in volleyball for both genders, despite its small population and lower income standards. Given this, it is crucial to examine why Serbian female volleyball players have achieved such outstanding success and to what extent anthropometric characteristics, as well as appropriate and timely player specialization, contribute to this success. By analyzing the specific characteristics and skills of young Serbian female volleyball players, we can gain insight into how timely specialization, taking into account the players' physical attributes, can play a key role in their success at international competitions.

An analysis and evaluation of the contemporary scientific literature revealed a lack of studies based on the assessment of differences in anthropometric and motor characteristics between different player positions at the elite level in Serbia. In line with that, the aim of our study is to examine the existence of differences in the anthropometric characteristics and motor abilities of young elite female volleyball players in relation to playing position.

2. Materials and Methods

This study was conducted on 114 young female volleyball players who were candidates for the U17 national selection of the Serbian national team (age: 15.4 $\pm$ 0.4 yrs.; body mass: 65.8 $\pm$ 7.8 kg; body height: 176.8 $\pm$ 7.7 cm The participants had at least four years of volleyball training experience, training 4 to 6 times per week, with each session lasting between 1.5 and 2 h. They did not have any additional training outside of this testing. Participants were healthy and without injuries that could compromise tested performance, nor were they consuming drugs, medications, or dietary supplements that could have influenced the tested physical performance. Before this study began, the volleyball players were informed about the test protocol and the research objectives. This study was conducted according to the principles of the Helsinki Declaration, as well as with the approval of the Ethics Committee of the Faculty of Sports and Physical Education of the University of Belgrade (484/2).

2.1. Testing Procedure

This study included participants from all playing positions: 14 liberos, 32 middle blockers, 16 opposite hitters, 36 outside hitters, and 16 setters. Testing was conducted over two consecutive days in a volleyball hall, from 9:00 AM to 12:00 PM. At the beginning of the testing, the anthropometric characteristics of the participants were measured. To minimize the impact of warm-up on the results of mobility and flexibility tests, these tests were

conducted after the anthropometric measurements, followed by the measurement of motor abilities. Each test station had its own measurer who carried out precise measurements and supervised the execution of tests according to standardized procedures. The testing was conducted by 10 experienced measurers: professors from the faculty, the authors of this study, and coaches with experience in conducting such measurements. Each participants underwent a 10 min warm-up [34], which was identical to the one they typically use during their regular training sessions. Afterward, the participants went through various test stations, which covered the following areas: medicine ball throw, vertical and horizontal jump, agility test, and sprint performance. Participants could perform each test up to three times, except for the flexibility test (sit and reach), where they were allowed two attempts. The participants were divided into two groups: the first group (57 participants) was tested on the first day, and the second group (57 participants) was tested on the second day. In this research, the following anthropometric measures were used:

- Body mass (BM)—measured using portable bioelectrical impedance (In Body 270, USA).
- The Martin anthropometer was used to measure body height (BH), sitting height (SH), one-arm standing reach (1ASR), two-arm standing reach (2ASR), and arm span. The results were recorded with an accuracy of 0.1 cm. Body mass index (BMI) was determined according to the TM/TV^2 formula [35].
- Volumes: upper arm circumference (CUA), forearm circumference (CF), chest circumference (CC), waist circumference (CW), hips circumference (CH), upper leg circumference (CUL), and lower leg circumference (CLL) were measured with a centimeter ribbon.
- For the assessment of subcutaneous fat tissue, the following measurements were taken from participants: chest skinfold (SC), midaxillary skinfold (SM), triceps skinfold (STR), subscapular skinfold (SS), suprailiac skinfold (SIS), abdominal skinfold (SAB), and front thigh skinfold (SFT). The results of the estimated fatty tissue were determined according to the Jackson Pollock 7 Caliper Method [36].
- Motor abilities were assessed using established protocols and standardized tests.

Flexibility test

- Sit and reach (SIR), a test for assessing hip joint flexibility and the lumbar region of the spine, was conducted in accordance with the procedure described by López-Miñarro et al. [37]. The results were read with a precision of 0.1 cm. A meter rule was placed on the sit-and-reach box, with the 23 cm mark aligned with the heel position. Reaches beyond the toes were recorded as positive, and those short of the toes as negative. In the sit-and-reach test, participants sat with their feet hip-width apart, keeping their knees extended. They placed their right hand over their left and slowly reached forward, sliding their hands along the measuring board. Participants performed the test twice, with a 1 min rest between attempts.
- The shoulder circumduction test (SCT) measures shoulder flexibility and involves measuring the arm length from the acromion to the metacarpal phalanx joint of the middle finger. The participant held a cord with a fixed and sliding handle, passed it over their head, and reached as far back as possible with extended arms. The score was calculated using a formula based on the shift in the sliding handle and arm length, with a higher score indicating better shoulder flexibility, as described in the protocol outlined by Lemmink et al. [38]. Participants performed the test three times, with a 1 min rest between attempts.

Medicine ball throw

- The medicine ball throw (MT) test was used to assess explosive power for an analogous total body movement pattern [39]. The medicine ball throw was performed using a 2 kg ball. The participant started in a standing position with the ball held above the head. The athletes were instructed to throw the ball over their heads as far as possible, with the distance of each throw measured in centimeters. Participants performed the test three times, with a 2 min rest between attempts.

Vertical and horizontal jump

To assess jumping ability and explosive leg power, we employed the squat jump (SJ), squat jump with arm swing (SJA), squat jump with hands on chest (SJC), countermovement jump without an arm swing (CMJ), and countermovement jump with an arm swing (CMJA) tests [40–42]. All jump tests were performed in 3 trials, with a 2 min rest between each trial to allow for adequate recovery and to achieve maximal performance.

- The SJ test began with the subject in a standing position, with their knees flexed at 90 degrees and feet placed hip-width apart. The subject's hands remained on their hips throughout the test. From this static position (without any pre-stretching), the subject performed a quick upward vertical jump, aiming to jump as high as possible.
- The SJA test began with the subject in a standing position, with knees flexed at 90 degrees and feet placed hip-width apart. The subject's arms were initially raised above the head. During the jump, the arms were swung to assist the movement. From this static position (without any pre-stretching), the subject performed a quick upward vertical jump, aiming to jump as high as possible, utilizing the arm swing to increase jump height.
- The CMJ test begins with the subject in an upright position, with their feet placed hip-width apart and knees slightly bent. The hands are positioned on the hips. From this static position, the subject quickly lowers into a squat, and then from the squat, performs an explosive upward jump, aiming to jump as high as possible.
- The CMJA test begins with the subject in an upright position, with their feet placed hip-width apart and knees slightly bent. The arms are raised above the head in a position of elevation. From this static position, the subject quickly lowers into a squat, using their arms to assist the movement. Then, from the squat position, they perform an explosive upward jump, aiming to jump as high as possible, utilizing the arm swing to increase jump height.
- The standing long jump (SLJ) serves as a field test for evaluating explosive leg power or the ability to generate force horizontally [43] and was conducted according to the protocol described by Almuzaini et al. [44].

A flat, non-slippery surface with a marked take-off point, with the take-off and landing areas at the same level. The examinee jumps with both feet from behind the take-off line and lands as far as possible. Both feet must land simultaneously. Each examinee is allowed two attempts. Any improperly executed jump must be repeated. The measurement point is the location where the heel first contacts the surface, closest to the take-off line. The measurement is recorded in centimeters, with the longest jump being noted. The jump should be performed with both feet taking off simultaneously. Examinees are allowed to rise onto their toes before take-off.

Agility test

One agility test was conducted, namely, a *t*-test. The *t*-test procedure is described in the study by Sekulic [45]. For the *t*-test agility test, the participants performed 3 trials with a 2 min rest between each trial to allow for recovery and to ensure more accurate results.

For the *t*-test, four cones were arranged in a T-shape. One cone was placed 9.14 m from the starting cone, and two additional cones were positioned 4.57 m on either side of the second cone. All times were recorded using an electronic timing gate (Brower timing system) with a height of 0.75 m and a width of 3 m, aligned with the marked starting point.

Participants were instructed to sprint 9.14 m forward from the start line to the first cone and touch its tip with their right hand. They then shuffled 4.57 m to the left to the second cone, touching its tip with their left hand, followed by shuffling 9.14 m to the right to the third cone, touching it with their right hand. Finally, they shuffled 4.57 m back to the left to the middle cone and touched its tip with their left hand. The last step required them to backpedal to the start line.

Timing began with a sound signal and stopped when the participant passed through the timing gate on their return. The trial was deemed unsuccessful if the participant

failed to touch a designated cone, crossed their legs while shuffling, or did not maintain a forward-facing position at all times. Time was recorded in hundredths of a second.

Sprint performance

The 5 m sprint (S5), 15 m sprint with a flying start (S15), and 20 m sprint (S20) were used for measuring acceleration and sprinting ability over short distances, which should be particularly important for volleyball. Testing procedures are thoroughly explained in previous studies [46,47]. The results were obtained with an accuracy of 0.1 s. For the sprint test, participants performed 3 trials with a rest period of 2 min between each attempt to ensure sufficient recovery and optimal performance in each trial.

The subjects were instructed to start with their preferred foot forward, placed on a line marked on the floor, and to run as fast as possible over a 20 m distance from a stationary standing start. Times were recorded at 5 m (the first electronic timing gate), 15 m (the second electronic timing gate), and 20 m (the third electronic timing gate). For tests, subjects performed three trials with a 3–4 min rest between trials (1 min for balance tests), and the best trial was used for further analysis.

2.2. Statistical Analyses

Data are presented as mean ± SD values and CV% (coefficient of variations). Before any statistical analysis, the normal distribution of the data (Shapiro–Wilk test) was confirmed ($p > 0.05$). For data analysis, G*Power software (version 3.1, Universität Düsseldorf, Düsseldorf, Germany) was used to determine the sample size, with the desired significance level ($\alpha = 0.05$), effect size (d = 0.40), number of groups (5), and power (0.95). According to the G*Power analysis, the recommended sample size for achieving the desired statistical power is 125, while the actual sample size in this study is 114. Although a smaller sample size may seem like a limitation, additional statistical indicators such as the intraclass correlation coefficient, coefficient of variation, and confidence intervals confirm the reliability of the results. These factors suggest that the smaller sample size does not significantly undermine the power and validity of this study, and the results remain statistically valid. A one-way analysis of variance (ANOVA) was used to determine differences in anthropological characteristics between playing positions among the entire player group. When a significant F value was achieved, pairwise differences between mean values were identified using with Bonferroni post-hoc procedures. For the calculation of effect size, we used a one-way analysis of variance (ANOVA), which automatically provides the relevant effect size values (e.g., partial eta squared). This statistical method allowed for us to assess the magnitude of differences between the groups in relation to the dependent variable. For the reliability of the measurements, we used confidence intervals (CI), coefficient of variation, and the intraclass correlation coefficient (ICC). All statistical tests were performed using the software package SPSS version 20.0 (SPSS, Inc., Chicago, IL, USA). Significance was set a $p \leq 0.05$.

3. Results

Table 1 shows the descriptive indicators for the original variables of body composition in relation to the playing position. Based on the results, it can be claimed that all variables are homogeneous because the coefficient of variation is in the range of 1.29–44.71 (CV%). The opposite hitter is the heaviest and tallest compared to all positions. The libero is generally the shortest player and has the lowest body mass in the team, which is reflected in the lowest values for SH, 1ASR, 2ASR, and arm span. The opposite hitter is the heaviest player on the team, and along with the middle blocker, the tallest player. They have the highest values in arm span, 2ASR, 1ASR, and SH. The outside hitter and setter have almost identical values for height, body mass, SH, and arm span. However, the setter has higher values for 1ASR and 2ASR due to the nature of the position. Since the setter plays at the net and, for most of the match, is involved in blocking the opposing team, height with extended arms becomes significant for this position.

Table 1. Descriptive statistics of body composition.

Variables	Position	N	Mean&Std	CV%	95% CI		ICC	ES
					Lower Bound	Upper Bound		
AGE	Libero	14	15.4 ± 0.52	3.33	15.13	15.73	0.805	
	Middle blocker	32	15.4 ± 0.51	3.26	15.26	15.62	0.666	
	Opposite hitter	16	15.6± 0.5	3.2	15.36	15.89	0.466	
	Outside hitter	36	15.3 ± 0.48	3.12	15.17	15.50	0.798	
	Setter	16	15.4 ± 0.5	3.25	15.11	15.64	0.491	
BM (kg)	Libero	14	61.8 ± 8.68	14.05	56.77	66.80	0.805	
	Middle blocker	32	68.7 ± 7.91	11.5	65.89	71.59	0.666	
	Opposite hitter	16	70.1 ± 5.99	8.55	66.87	73.25	0.466	15%
	Outside hitter	36	63 ± 7.03	11.16	60.64	65.40	0.798	
	Setter	16	66.1 ± 6.98	10.57	62.34	69.78	0.491	
BH (cm)	Libero	14	164 ± 8.68	3.05	161.52	167.31	0.805	
	Middle blocker	32	183 ± 7.91	3.08	180.48	184.53	0.666	
	Opposite hitter	16	182 ± 5.99	1.37	180.76	183.41	0.466	56%
	Outside hitter	36	176 ± 7.03	3.4	173.59	177.63	0.798	
	Setter	16	174 ± 0.5	2.92	171.55	176.98	0.491	
BMI ($kg \cdot m^{-2}$)	Libero	14	22.7 ± 2.47	10.86	21.31	24.16	0.805	
	Middle blocker	32	20.6 ± 1.80	8.76	19.95	21.25	0.666	
	Opposite hitter	16	21.2 ± 1.69	7.96	20.26	22.06	0.466	14%
	Outside hitter	36	20.5 ± 2.09	10.24	19.75	21.17	0.798	
	Setter	16	21.7 ± 1.59	7.32	20.86	22.55	0.491	
SH (cm)	Libero	14	88.9 ± 3.02	3.4	87.11	90.60	0.805	
	Middle blocker	32	95.2 ± 3.26	3.42	94.03	96.37	0.666	
	Opposite hitter	16	95.1 ± 1.83	1.92	94.09	96.04	0.466	33%
	Outside hitter	36	92.3 ± 3.33	3.61	91.22	93.48	0.798	
	Setter	16	91.8 ± 2.81	3.06	90.25	93.25	0.491	
CUA (cm)	Libero	14	25.8 ± 3.14	12.18	23.95	27.57	0.805	
	Middle blocker	32	24.3 ± 1.87	7.69	23.62	24.97	0.666	
	Opposite hitter	16	24.6 ± 1.7	6.91	23.74	25.56	0.466	5%
	Outside hitter	36	24.4 ± 2.15	8.83	23.65	25.11	0.798	
	Setter	16	24.5 ± 1.95	7.97	23.47	25.55	0.491	
CF (cm)	Libero	14	23.1 ± 1.85	7.98	22.05	24.18	0.805	
	Middle blocker	32	22.8 ± 1.41	6.18	22.29	23.30	0.666	
	Opposite hitter	16	22.9 ± 1.48	6.46	22.09	23.66	0.466	2%
	Outside hitter	36	22.6 ± 1.23	5.43	22.20	23.03	0.798	
	Setter	16	23 ± 0.96	4.17	22.53	23.55	0.491	
CC (cm)	Libero	14	83.8 ± 4.89	5.84	80.95	86.59	0.805	
	Middle blocker	32	86.2 ± 4.66	5.41	84.49	87.86	0.666	
	Opposite hitter	16	87.3 ± 3.28	3.76	85.58	89.07	0.466	8%
	Outside hitter	36	84.3 ± 3.73	4.43	83.09	85.61	0.798	
	Setter	16	86.3 ± 4.95	5.74	83.61	88.89	0.491	
CW (cm)	Libero	14	70.9 ± 5.95	8.39	67.44	74.30	0.805	
	Middle blocker	32	73.9 ± 4.84	6.55	72.18	75.67	0.666	
	Opposite hitter	16	74.9 ± 2.59	3.46	73.49	76.26	0.466	10%
	Outside hitter	36	71 ± 4.92	6.93	69.32	72.65	0.798	
	Setter	16	72.4 ± 5.24	7.23	69.61	75.19	0.491	
CH (cm)	Libero	14	96.4 ± 6.98	7.24	92.41	100.47	0.805	
	Middle blocker	32	98.2 ± 4.79	4.88	96.44	99.89	0.666	
	Opposite hitter	16	98.3 ± 4.47	4.55	95.89	100.66	0.466	4%
	Outside hitter	36	96 ± 5.66	5.9	94.03	97.87	0.798	
	Setter	16	98.6 ± 4.32	4.38	96.30	100.90	0.491	
CUL (cm)	Libero	14	55.9 ± 6.12	10.96	52.35	59.42	0.805	
	Middle blocker	32	53.5 ± 3.88	7.26	52.08	54.88	0.666	
	Opposite hitter	16	52.5 ± 3.85	7.34	50.47	54.58	0.466	4%
	Outside hitter	36	53.6 ± 3.88	7.25	52.25	54.87	0.798	
	Setter	16	54.1 ± 4.59	8.49	51.69	56.59	0.491	

Legend: mean and standard deviation—Mean&Std; coefficient of variation—CV%; 95% confidence interval—95% CI; intraclass correlation coefficient—ICC; effect size—ES; body mass—BM; body height—BH; body mass index—BMI; sitting height—SH; upper arm circumference—CUA; forearm circumference—CF; chest circumference—CC; waist circumference—CW; hip circumference—CH; upper leg circumference—CUL.

Tables 1–3 show the ICC values for different positions. The data for the libero and outside hitter positions are very reliable due to the high consistency in measurements. For the middle blocker, although the ICC value is lower than that of the libero and outside hitter, the value of 0.666 still indicates good reliability. The ICC values for the opposite hitter and setter fall below 0.50, suggesting moderate reliability. These values indicate that most of the variability is due to actual differences between positions.

Table 2. Descriptive statistics of body composition.

Variables	Position	N	Mean&Std	CV%	95% CI		ICC	ES
					Lower Bound	Upper Bound		
CLL (cm)	Libero	14	36.9 ± 2.19	5.92	35.68	38.20	0.805	2%
	Middle blocker	32	36.1 ± 2.42	6.71	35.20	36.94	0.666	
	Opposite hitter	16	36.1 ± 2.21	6.13	34.96	37.32	0.466	
	Outside hitter	36	35.8 ± 2.42	6.76	34.95	36.59	0.798	
	Setter	16	36.3 ± 1.92	5.29	35.24	37.29	0.491	
SC (mm)	Libero	14	7.26 ± 2.24	30.93	5.96	8.55	0.805	6%
	Middle blocker	32	6.07 ± 1.56	25.76	5.51	6.63	0.666	
	Opposite hitter	16	5.7 ± 1.1	19.24	5.12	6.28	0.466	
	Outside hitter	36	6.23 ± 1.66	26.72	5.66	6.79	0.798	
	Setter	16	6.24 ± 1.82	29.22	5.27	7.21	0.491	
SM (mm)	Libero	14	10.2 ± 2.31	22.69	8.85	11.52	0.805	3%
	Middle blocker	32	9.32 ± 1.9	20.41	8.63	10.00	0.666	
	Opposite hitter	16	9.53 ± 1.41	14.84	8.77	10.28	0.466	
	Outside hitter	36	8.93 ± 2.4	26.91	8.12	9.75	0.798	
	Setter	16	9.76 ± 2.99	30.6	8.17	11.35	0.491	
STR (mm)	Libero	14	14.6 ± 4.78	32.76	11.84	17.36	0.805	2%
	Middle blocker	32	13.3 ± 4.91	36.98	11.52	15.06	0.666	
	Opposite hitter	16	14.7 ± 2.75	18.66	13.26	16.19	0.466	
	Outside hitter	36	14.2 ± 4.22	29.71	12.78	15.64	0.798	
	Setter	16	13.5 ± 2.79	20.6	12.05	15.02	0.491	
SS (mm)	Libero	14	11.1 ± 1.96	17.68	9.98	12.25	0.805	6%
	Middle blocker	32	11.2 ± 3.49	31.27	9.90	12.41	0.666	
	Opposite hitter	16	11.1 ± 1.16	10.51	10.45	11.70	0.466	
	Outside hitter	36	9.49 ± 3.28	34.58	8.38	10.61	0.798	
	Setter	16	10.5 ± 3.04	28.99	8.86	12.09	0.491	
SIS (mm)	Libero	14	10.3 ± 2.61	25.33	8.79	11.81	0.805	2%
	Middle blocker	32	10.1 ± 3.49	34.66	8.80	11.31	0.666	
	Opposite hitter	16	9.76 ± 1.99	20.43	8.70	10.83	0.466	
	Outside hitter	36	9.02 ± 4.03	44.71	7.65	10.38	0.798	
	Setter	16	9.56 ± 2.36	24.63	8.31	10.82	0.491	
SAB (mm)	Libero	14	19.2 ± 6.19	32.3	15.60	22.75	0.805	7%
	Middle blocker	32	20.2 ± 5.21	25.77	18.32	22.08	0.666	
	Opposite hitter	16	19.2 ± 3.09	16.07	17.59	20.88	0.466	
	Outside hitter	36	16.5 ± 6.42	39.03	14.28	18.63	0.798	
	Setter	16	18.6 ± 5.77	31.09	15.49	21.64	0.491	
SFT (mm)	Libero	14	26.1 ± 6.43	24.69	22.34	29.77	0.805	12%
	Middle blocker	32	21.1 ± 5.28	25.05	19.19	23.00	0.666	
	Opposite hitter	16	23.5 ± 3.72	15.84	21.52	25.48	0.466	
	Outside hitter	36	21 ± 5.77	27.48	19.03	22.93	0.798	
	Setter	16	24.7 ± 4.23	17.1	22.48	26.99	0.491	
1ASR (cm)	Libero	14	222 ± 16.40	7.19	215.25	233.90	0.805	16%
	Middle blocker	32	231 ± 16.10	6.97	225.57	237.21	0.666	
	Opposite hitter	16	236 ± 4.79	2.03	232.95	238.05	0.466	
	Outside hitter	36	218 ± 19.8	9.09	211.00	224.39	0.798	
	Setter	16	224 ± 8.42	3.76	219.45	228.42	0.491	

Table 2. *Cont.*

Variables	Position	N	Mean&Std	CV%	95% CI		ICC	ES
					Lower Bound	Upper Bound		
2ASR (cm)	Libero	14	222 ± 16.40	7.4	212.72	231.70	0.805	16%
	Middle blocker	32	230 ± 15.80	6.87	223.88	235.25	0.666	
	Opposite hitter	16	233 ± 5.12	2.2	230.14	235.61	0.466	
	Outside hitter	36	215 ± 19.5	9.06	208.81	222.02	0.798	
	Setter	16	221 ± 9.06	4.09	216.55	226.20	0.491	
Arm span (cm)	Libero	14	167 ± 5.57	3.34	163.35	169.79	0.805	55%
	Middle blocker	32	185 ± 5.75	3.11	182.49	186.63	0.666	
	Opposite hitter	16	183 ± 2.36	1.29	182.12	184.63	0.466	
	Outside hitter	36	178 ± 5.72	3.22	175.79	179.66	0.798	
	Setter	16	176 ± 4.84	2.76	172.92	178.08	0.491	

Legend: mean and standard deviation—Mean&Std; coefficient of variation—CV%; 95% confidence interval—95% CI; intraclass correlation coefficient—ICC; effect size—ES; one arm standing reach—1ASR; two arms standing reach—2ASR; lower leg circumference—CLL; chest skinfold—SC (mm); midaxillary skinfold—SM; triceps skinfold—STR; subscapular skinfold—SS; suprailiac skinfold—SIS; abdominal skinfold—SAB; front thigh skinfold—SFT.

Table 3. Descriptive statistics of motor abilities.

Variables	Position	N	Mean&Std	CV%	95% CI		ICC	ES
					Lower Bound	Upper Bound		
TT (s)	Libero	14	10.4 ± 0.43	4.16	10.16	10.66	0.805	20%
	Middle blocker	32	10.9 ± 0.41	3.73	10.73	11.02	0.666	
	Opposite hitter	16	11.3 ± 0.47	4.14	11.03	11.53	0.466	
	Outside hitter	36	11 ± 0.54	4.91	10.81	11.18	0.798	
	Setter	16	10.9 ± 0.45	4.15	10.64	11.13	0.491	
S20 (s)	Libero	14	3.39 ± 0.13	3.75	3.32	3.47	0.805	14%
	Middle blocker	32	3.49 ± 0.14	3.87	3.44	3.54	0.666	
	Opposite hitter	16	3.58 ± 0.14	3.69	3.51	3.65	0.466	
	Outside hitter	36	3.48 ± 0.15	4.45	3.43	3.53	0.798	
	Setter	16	3.55 ± 0.08	2.41	3.51	3.60	0.491	
S15 (s)	Libero	14	2.25 ± 0.09	4.14	2.20	2.31	0.805	15%
	Middle blocker	32	2.28 ± 0.09	4.02	2.25	2.32	0.666	
	Opposite hitter	16	2.39 ± 0.08	3.62	2.35	2.44	0.466	
	Outside hitter	36	2.32 ± 0.11	4.7	2.28	2.35	0.798	
	Setter	16	2.3 ± 0.074	3.24	2.26	2.34	0.491	
S5 (s)	Libero	14	1.14 ± 0.03	2.73	1.12	1.15	0.805	22%
	Middle blocker	32	1.2 ± 0.07	5.98	1.17	1.22	0.666	
	Opposite hitter	16	1.18 ± 0.06	4.84	1.15	1.21	0.466	
	Outside hitter	36	1.16 ± 0.05	4.72	1.14	1.18	0.798	
	Setter	16	1.24 ± 0.06	5.18	1.20	1.27	0.491	
CMJA (cm)	Libero	14	36.1 ± 5.7	16.01	32.77	39.45	0.805	7%
	Middle blocker	32	38.7 ± 5.03	13	36.84	40.47	0.666	
	Opposite hitter	16	35.1 ± 4.09	11.65	32.88	37.23	0.466	
	Outside hitter	36	37.2 ± 4.27	11.48	35.78	38.67	0.798	
	Setter	16	37.8 ± 3.14	8.31	36.15	39.49	0.491	
CMJ (cm)	Libero	14	31.2 ± 3.05	9.78	29.41	32.93	0.805	13%
	Middle blocker	32	32.8 ± 3.56	10.85	31.51	34.08	0.666	
	Opposite hitter	16	29.4 ± 1.82	6.19	28.40	30.34	0.466	
	Outside hitter	36	31.2 ± 2.76	8.85	30.30	32.17	0.798	
	Setter	16	32.5 ± 3.06	9.42	30.83	34.10	0.491	
SJC (cm)	Libero	14	31 ± 4.11	13.26	28.62	33.37	0.805	7%
	Middle blocker	32	33.4 ± 4.47	13.38	31.74	34.96	0.666	
	Opposite hitter	16	30.5 ± 2.12	6.95	29.40	31.66	0.466	
	Outside hitter	36	32.1 ± 2.93	9.13	31.15	33.13	0.798	
	Setter	16	32.6 ±3.91	11.99	30.52	34.68	0.491	

Table 3. *Cont.*

Variables	Position	N	Mean&Std	CV%	95% CI		ICC	ES
					Lower Bound	Upper Bound		
SJA (cm)	Libero	14	35.5 ± 4.87	13.72	32.69	38.31	0.805	4%
	Middle blocker	32	35.2 ± 5.09	14.46	33.38	37.05	0.666	
	Opposite hitter	16	32.6 ± 3.81	11.69	30.59	34.64	0.466	
	Outside hitter	36	34.7 ± 3.85	11.1	33.37	35.97	0.798	
	Setter	16	33.7 ± 4.04	11.99	31.56	35.86	0.491	
SJ (cm)	Libero	14	29 ± 3.24	11.17	27.16	30.90	0.805	12%
	Middle blocker	32	29.4 ± 3.3	11.22	28.19	30.57	0.666	
	Opposite hitter	16	26.1 ± 2.43	9.31	24.78	27.37	0.466	
	Outside hitter	36	28.1 ± 3.22	11.46	27.01	29.19	0.798	
	Setter	16	29.1 ± 2.29	7.87	27.86	30.29	0.491	
SLJ (cm)	Libero	14	205 ± 20.1	9.8	192.99	216.15	0.805	22%
	Middle blocker	32	197 ± 32.6	16.55	184.88	208.37	0.666	
	Opposite hitter	16	219 ± 14.1	6.44	211.35	226.40	0.466	
	Outside hitter	36	176 ± 29.4	16.7	165.78	185.66	0.798	
	Setter	16	198 ± 27.8	14.04	183.19	212.81	0.491	
MT (cm)	Libero	14	8.91 ± 1.77	19.87	7.88	9.93	0.805	14%
	Middle blocker	32	8.89 ± 2.28	25.65	8.07	9.71	0.666	
	Opposite hitter	16	9.63 ± 1.13	11.73	9.03	10.23	0.466	
	Outside hitter	36	7.27 ± 2.65	36.45	6.38	8.17	0.798	
	Setter	16	8.84 ± 1.55	17.53	8.02	9.67	0.491	
SCT (cm)	Libero	14	65.4 ± 18.5	28.29	54.76	76.09	0.805	5%
	Middle blocker	32	66.4 ± 16.8	25.3	60.38	72.49	0.666	
	Opposite hitter	16	66.5 ± 21.1	31.73	55.26	77.74	0.466	
	Outside hitter	36	71 ± 14.9	20.99	65.95	76.05	0.798	
	Setter	16	76.3 ± 9.63	12.62	71.12	81.38	0.491	
SIR (cm)	Libero	14	23.6 ± 8.55	36.23	18.66	28.54	0.805	12%
	Middle blocker	32	15 ± 8.34	55.6	12.02	18.03	0.666	
	Opposite hitter	16	15 ± 7.47	49.8	11.01	18.97	0.466	
	Outside hitter	36	19.4 ± 7.52	38.76	16.84	21.93	0.798	
	Setter	16	22.2 ± 13	58.56	15.33	29.14	0.491	

Legend: mean and standard deviation—Mean&Std; coefficient of variation—CV%; 95% confidence interval—95% CI; intraclass correlation coefficient—ICC; effect size—ES; sit and reach—SIR; medicine ball throw—MT; standing long jump—SLJ; squat jump—SJ; squat jump with arm swing—SJA; squat jump with hands on chest—SJC; countermovement jump without an arm swing—CMJ; countermovement jump with an arm swing—CMJA; 5 m sprint—S5; 15 m sprint with a flying start—S15; 20 m sprint—S20; *t*-test—TT.

Table 3 shows the descriptive indicators for the tested variables in relation to the playing position. Based on the results, it can be claimed that all variables are homogeneous because the coefficient of variation is in the range of 2.41–58.56 (CV%). The histogram showed that there were four individual cases (extreme values) with lower SIR and SCT values. A closer examination of the database revealed that these individuals achieved poorer results due to lower shoulder girdle flexibility, hamstring, and lower back.

Based on the results in Table 3, it can be concluded that the libero achieved the best results in the *t*-test, the 5 m sprint, and flexibility tests. Given the nature of the libero's position on the team, agility is of great importance due to frequent direction changes, as well as short sprints, which are crucial when balls arrive from the opposing team. Additionally, flexibility is important for getting into the lowest squat positions during defense. The opposite hitter has somewhat lower results in the jump tests, which can be explained by the fact that she is the tallest player on the team, meaning she has longer arms and a larger body, so her jump height may be different compared to, for example, the libero. However, she has the highest results in the SLJ, which is typical for her position, as she usually has the greatest momentum and is also responsible for spiking from the back row of the court. However, she achieves the best results in the MT, making her the most explosive player on the team. The middle blocker has the best results in the jump tests, as these players are constantly involved in both blocking and attacking against the opposing team. The outside hitter achieved high values in all the jump tests, except SLJ. The reason for this

may be the fact that these players are specialized in movements that involve speed and coordination. The setter is characterized by achieving good results in almost all jump tests. However, somewhat lower results, compared to other positions, were observed in the SCT test. One of the factors that can contribute to reduced shoulder mobility is repetitive movements, particularly those that are frequently repeated in similar patterns. In this case, the technician is often exposed to movements involving lifting the ball during spiking.

The effect size percentages for the statistically significant variables, as determined by univariate ANOVA, are presented below (Tables 1–3). For the variables BH and arm span, the results of the ANOVA show that 55% of the variance in both height and arm span are explained by differences between player positions (libero, setter, outside hitter, opposite, and middle blocker). This result indicates that the player's position has a very significant impact on both height and arm span, meaning that these characteristics are largely dependent on the player's position in the team. For example, players in the middle blocker and outside hitter positions are significantly taller than players in the libero and setter positions, which is expected given the physical demands of these positions (middle blockers and outside hitters often require greater height for effective blocking and attacking). This substantial effect highlights the link between physical characteristics (such as height and arm span) and the specific functions required by each player position. The differences in height and arm span between positions explain as much as 55% of the total variance in both characteristics. A large effect size was observed in the variables *t*-test, S20, S15, S5, SLJ, MT, 2ASR, 1ASR, SH, BMI, and BM with partial eta squared values ranging from 14% to 33%. These values are considered to indicate a large effect, meaning that the player's position in the team has a significant impact on variations in these variables, explaining a substantial portion of their total variance. For CMJ, SJ, SIR, and CW, a moderate effect size was observed, with partial eta squared values ranging from 6% to 13%, suggesting a moderate impact of the player's position on these variables.

The results of the ANOVA showed that there were significant differences in the values of BM, BH, BMI, 1ARS, 2ARS, arm span, MT, SLJ, SJ, CMJ, S5, S15, S20, and TT. The results of the Bonferroni post-hoc test are presented in Table 4.

Table 4. Difference among positions in the tested variables (mean).

	F	SIG.	Libero (L)	Middle Blocker (MB)	Opposite Hitter (O)	Outside Hitter (R)	Setter (S)
BM (kg)	4.936	0.001	61.786 $^{\times\$}$	68.738 $^{*£}$	70.063 $^{*£}$	63.017 $^{\times\$}$	66.063
BH (cm)	33.990	0.000	164.414 $^{\times\$£\hat{}}$	182.506 $^{*£\hat{}}$	182.087 $^{*£\hat{}}$	175.611 $^{*\times\$}$	174.263 $^{*\times\$}$
BMI	4.334	0.003	22.739 $^{\times£}$	20.601 $^{£}$	21.161 *	20.458	21.707
1ARS (cm)	5.074	0.001	224.57	231.39 $^{£}$	235.50 $^{£}$	217.69 $^{\times\$}$	223.94
2ARS (cm)	5.234	0.001	222.21	229.56 $^{£}$	232.88 $^{£}$	215.42 $^{\times\$}$	221.38
ARM SPAN (cm)	33.600	0.000	166.57 $^{\times\$£\hat{}}$	184.56 $^{*£\hat{}}$	183.38 $^{*£\hat{}}$	177.72 $^{*\times\$}$	175.50 $^{*\times\$}$
SIR (cm)	3.873	0.006	23.600 $^{\times}$	15.025 *	14.988	19.389	22.238
MT (cm)	4.552	0.002	8.9071	8.8906 $^{£}$	9.6313 $^{£}$	7.2706 $^{*\times\$}$	8.8438
SLJ (cm)	7.870	0.000	204.57 $^{£}$	196.63 $^{£}$	218.88 $^{£}$	175.72 $^{*\times\$}$	198.00
SJ (cm)	3.613	0.008	29.029	29.379 $^{\$}$	26.076 $^{\times}$	28.099	29.075
CMJ (cm)	4.061	0.004	31.169	32.798 $^{\$}$	29.368 $^{\times\hat{}}$	31.237	32.463 $^{\$}$
S5 (s)	7.470	0.000	1.135 $^{\times\hat{}}$	1.195 *	1.182	1.157 $^{\hat{}}$	1.237 $^{*£}$
S15 (s)	4.986	0.001	2.253 $^{\$}$	2.283$^{\$}$	2.393 $^{*\times}$	2.315	2.301
S20 (s)	4.582	0.002	3.394 $^{\$\hat{}}$	3.488	3.584 *	3.479	3.554 *
TT (s)	6.766	0.000	10.408 $^{\times\$£}$	10.878*	11.278 *	10.995 *	10.885

Legend: *—significantly different from libero ($p < 0.05$) L; $^{\times}$—significantly different from middle blocker ($p < 0.05$) MB; $^{\$}$—significantly different from opposite hitter ($p < 0.05$) O; $^{£}$—significantly different from outside hitter ($p < 0.05$) R; $^{\hat{}}$—significantly different from setter ($p < 0.05$) S.

4. Discussion

The present study investigated differences between the anthropological characteristics and motor abilities of young elite female volleyball players in relation to playing positions. The main result of this study demonstrates significant differences in anthropological characteristics and motor abilities in connection with playing positions. There are significant differences for BM, BH, BMI, 1ARS, 2ARS, arm span, SIR, MT, SLJ, SJ, CMJ, S5, S15, S20, and TT.

Table 4 shows significant differences between playing positions, for example, in BM, the libero is significantly different compared to the middle blocker and opposite hitter; the middle blocker and opposite hitter have significant differences in comparison to the libero and outside hitter. Results indicate that the libero has lesser values of body mass, which can be explained by the nature of this playing position; these results are the same as the result of Jahandideh et al. [48]. Usually, the libero has lesser values of BH and BM, because the position demands a lower bodily center of gravity from the player. Accordingly, for players who have higher values of BM and BH, getting into the defensive position is much harder and slower than for the libero. When it comes to the BH of the libero and outside hitter, the results show that they differ significantly in comparison to other positions. These positions have lesser values of BH, as the opposite hitter has higher values of BH compared to the libero, outside hitter, and setter. The results show that the middle blocker and opposite hitter were the tallest and heaviest players in the team, but the smallest and the lightest were libero players (Table 4); other studies have confirmed these results with elite samples of participants [19,39]. Findings indicate that the middle blockers and the opposite hitters are the tallest (201.57 $\pm$ 4.92 cm; 203.00 $\pm$ 4.41 cm) and heaviest (86.14 $\pm$ 6.79 kg; 91.60 $\pm$ 6.69 kg) players in the team [19]. This is because the position of the opposite hitter demands higher effectiveness in attack in the match; usually, they are the highest in the team. Namely, higher values of body height are associated with higher efficiency in the game; the reason for this is a larger reach point, longer levers, and better angle of attack. Also, setters have significantly lower values of BH than opposite hitters and middle blockers. In variable BMI, there are significant differences among libero, middle blocker, and outside hitter, where the libero has the highest values of BMI (+2.21); this is expected, in relation to their body composition. In volleyball, it has been shown that player movement depends on BMI. Players with a higher BMI move more slowly on the court compared to those with a lower BMI, all else being equal in terms of strength and skill [49]. The results from the variables of one 1ASR and 2ASR are identical, whereas significant differences exist among opposite hitters (232.88 cm), middle blockers (229.56 cm), and outside hitters (215.42 cm). The study conducted by Milić et al. [16] aimed to determine differences in anthropometric and physical characteristics among young Croatian female volleyball players (aged 13 to 15) in relation to their playing positions and performance levels within each position. The results of their study showed similar findings in terms of a 20 m sprint (3.7 $\pm$ 0.2 s to 3.6 $\pm$ 0.2 s). Considering that the participants in our study were elite young volleyball players, it is evident that they exhibited better results in all the measured parameters compared to the study by Milić et al. [16]. These elite volleyball players were taller, heavier, and more explosive, while their 20 m sprint times were similar in both studies. Volleyball players participating in the elite Spanish league, with an average age of 24, have a higher BM compared to volleyball players from Serbia, although their BH and BMI are approximately similar [16]. The results of the study Pastuszak et al. show that volleyball players from the second league in Warsaw, with an average age of 21.6 years, have nearly identical values for BM and BH compared to Serbian junior volleyball players. However, it is evident that the elite nature of Serbian volleyball contributes to the higher level of physical characteristics [50].

Liberos have the smallest arm span values, while hitters and setters have similar and higher values. Libero is significantly different from all other positions, due to their body composition and position in the team, which has the role of defense in the field. The results in our study for the arm span variable are similar to those in the study by Cherouveim

et al. [51]. Arm span plays an important role for setters and hitters due to a larger reach point when spiking, as well as blocking opponents where players at the net are expected to cover more of the court and stop the opponent's attack. The main finding of the study [23] was that BMI, body size (BH and standing reach height), and reach height have accuracy (78.1%) for predicting who might be selected or non-qualified elite young female volleyball players. Also, the vertical jump, reach height, and body height are related to key elements of volleyball performance such as serving, blocking, and attacking.

Liberos and setters had significantly better flexibility in the lower back and hamstrings compared to hitters and middle blockers (Table 4). The results from Duncan et al. [7] indicate greater flexibility in hitters compared to opposites, while the results in the study by Cherouveim et al. [51] indicate lower values of SIR on average (14.4 cm) and almost similar results among positions. Although the subjects are elite, the results of our study indicate higher values of sit and reach on average (19.05 cm), as well as the presence of significant differences between positions (Table 4). These results can be explained by the positive effect of volleyball training on flexibility [52].

Upper body explosive power is a significant factor in volleyball success, particularly evident during spiking or serving, where this motion occurs most frequently. It has a dominant impact on jumping and the effectiveness of serving due to the increased speed of the ball after the hit [53]. Also, upper body strength in volleyball is essential for successful blocking and hitting, as well as injury prevention due to a high volume of shots during competition or practice. The opposite hitter has the longest throw distance (9.63 m), while the outside hitter has the lowest throw distance (7.27 m). The study conducted by Katić et al. [24] found that the vertical jump, spike jump reach, and medicine ball throw tests can predict player selection with high accuracy. Specifically, the medicine ball throw is a strong predictor of successful players and selection, as it measures explosive power and strength, which are key attributes for performance in volleyball, especially for positions like the outside hitter and opposite, where power and speed are crucial for both attacking and defense.

Significant differences were also observed in motor abilities, in SLJ comparing an outside hitter with a libero, middle blocker, and opposite hitter. The outside hitter has the lowest values of SLJ and the opposite hitter has the highest values. It is expected that elite volleyball players develop explosive strength to maximize their efficiency on the court. Opposite hitters, who are frequently positioned at the net for spiking and blocking, are therefore expected to have the highest values in the long jump. Given that the opposite hitter achieved the best results in this test (219 cm), this can be explained by the fact that this player is responsible for the highest number of attacks on the team, often executing attacks from the back row as well. This increased volume of jumping and attacking movements contributes to their superior performance in the long jump test.

Jumping ability is crucial for competitive success in volleyball, and it also significantly influences volleyball skills in the following ways: jumping higher allows for the server to play the ball with a flatter initial projection angle; it allows for the setter to decrease the time between the set and the attack; it allows for the attacker to spike over the block and the blocker to penetrate far over the net with her arms, thereby increasing the effectiveness of the block. The biomechanics of jumping involve the acceleration of the center of mass (CoM) prior to take-off, with greater force applied to the ground resulting in higher jump velocity and greater jump height. By extending the hips, knees, and ankles, athletes generate the necessary force to propel the CoM upward, which directly influences their jumping ability [54]. The ability to generate high force and tolerate high tendon tension in rapid stretch-shortening cycle movements is crucial for jump performance in volleyball. Liberos, middle blockers, setters, and outside hitters have higher values of SJ (29 cm), while opposite hitters have 26 cm on average. Given that opposite hitters execute numerous approach spike jumps during the game utilizing the stretch-shortening cycle (SSC), the squat jump is not as specifically common for opposite hitters as it is for middle blockers. The CMJ can increase jump height by 7% [55]. This increase is due to higher myoelectrical activity in the

stretch-shortening cycle (SSC), the storage and release of elastic energy, and a greater active state, i.e., increased motoneuron activity before the onset of muscle shortening [56]. In CMJ, the setter has the highest jump values (32.463 cm) compared to all other positions, and the opposite hitter has slightly lower values (29.368 cm). The apparent reason for this is that the setter, due to the nature of their position, constantly performs jumps when blocking, scoring points, and organizing attacks.

Sprint is an important segment in the motor area of a volleyball player in order to position the player in defense during the reception of the serve, defending the court or setting the ball for an attack, thus performing a high-quality jump when blocking or serving. Libero is a player in the team who remains in defensive position for most of the game; with a lower center of gravity, they must also be agile and ready to defend the field at any moment. Consequently, it is expected that their S20 result (1.135 s) will be better compared to the rest of the team, both due to their position and their physical composition in terms of height and weight. Statistically, the libero differs from the middle blocker (1.195 s) and the setter (1.237 s), who have slightly higher values in the S20. Additionally, differences are also present between the setter and the outside hitter. Volleyball is a dynamic game and consists of many explosive efforts, characterized by repeated attacks of high intensity with a short period of rest [21,57]. Elite volleyball players are expected to have well-developed motor skills to execute tactical tasks flawlessly. In the context of the dynamic nature of volleyball, in addition to other motor skills, players need to have developed speed and agility. Table 4 shows that all positions exhibit good values in the TT variable, as players are required to adopt an optimal position for effective court defense. However, the libero demonstrated the best values in this test. Given the nature of the libero's position on the team, agility is of great importance due to frequent direction changes, as well as short sprints, which are crucial when balls arrive from the opposing team. TT is highly reliable and measures a combination of components, including leg speed, strength, and agility [58].

Elite volleyball players competing in beach volleyball, with an average age of 21, achieve better results in jumps compared to young volleyball players from Serbia, while the values in agility tests, 5 m sprints, and medicine ball throws are similar [59]. The reason for the better jump results in beach volleyball players may be that they have already developed the specific strength and explosiveness required for this type of competition, while young volleyball players from Serbia are still in the phase of physical development. Specifically, athletes around the age of 21 already possess more developed muscle mass and strength, which enables them to achieve better performance in jumps. Additionally, the surface in beach volleyball is different from the hard court, which may contribute to the development of greater explosiveness due to the increased demand on the muscles for jumping and quick movements on sand. On the other hand, younger volleyball players from Serbia have not yet reached their full physical potential, which is why their results in this segment may be weaker.

Based on athletes' potential abilities, it is possible to predict the developmental path of female volleyball players [60]. The results of our study demonstrate the potential abilities and anthropological characteristics that volleyball players may possess depending on their position in the team, enabling timely specialization for young female volleyball players.

There have been studies examining the anthropological characteristics of young female volleyball players, where variables such as BM, BG, SLJ, SH, BMI, SIR, MT, S20, S5, TT, SJ, and CMJ were measured. Based on the literature review and in comparison to the results of our study, it can be argued that Serbian volleyball players are taller, more agile, faster, and stronger, which is expected considering the representativeness of the sample [16,30,51,53,61].

The limitations of this study include the cross-sectional nature of the design, which prevents tracking changes over time, as well as the limited representativeness of the sample, as data were collected only from volleyball players in one league. For future studies, it is recommended to track the development of motor abilities and changes in anthropometric characteristics during the transition from junior to senior levels of female volleyball players.

Such research would provide a better understanding of how motor abilities, strength, and explosiveness evolve throughout different stages of an athlete's career and how these changes impact performance at higher levels of competition. Additionally, it would be useful to include a more detailed analysis of body composition, for example, by using impedance scales to obtain data on body fat percentage and muscle mass, which would further enrich the insight into the athletes' physical conditioning.

These improvements could contribute to the understanding and standardization of physical characteristics of elite volleyball players, allowing for comparisons with athletes from other leagues or countries.

5. Conclusions

This study shows significant differences in the anthropometric characteristics and motor abilities among young elite female volleyball players depending on their position on the court. The libero, with a lower body mass and height, requires agility, speed, and flexibility, while middle blockers and opposite hitters, who are taller and heavier, focus on strength and jumping. Outside hitters and setters achieved high results in jump tests, while outside hitters, although agile, had slightly lower results in the long jump. The results confirm that BH and BM, 1ARS, 2ARS, arm span, explosive power, agility, speed, and flexibility significantly impact performance, indicating that a player's position affects their anthropometric characteristics and motor abilities.

Coaches should take into account the motor and anthropometric specifics of players when planning training, so that programs are tailored to the positions. For example, for the libero position, the focus should be on agility and flexibility, while for middle blockers and opposite hitters, it should be on strength, explosiveness, and jumping. Setters, given the demands of their position, should work on coordination, precision, and agility. This study can assist in the development of training programs for young female volleyball players, optimizing training for the specific skills of each position. Additionally, these results can serve as a basis for comparison with samples from other studies, particularly in the context of the elite sample of the Serbian volleyball team. Furthermore, these values are relevant for younger volleyball players, while future research should examine these characteristics and motor abilities at the first-team level to assess the current state and develop effective strategies for further development.

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