Anthropometric and physical characteristics allow differentiation of young female volleyball players according to playing position and level of expertise

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ABSTRACT: The aim of our study was to determine the differences in some anthropometric and physical performance variables of young Croatian female volleyball players (aged 13 to 15) in relation to playing position (i.e., independent variable) and performance level within each position (i.e., independent variable). Players were categorized according to playing position (i.e., role) as middle blockers (n=28), opposite hitters (n=41), passer-hitters (n=54), setters (n=30), and liberos (n=28). Within each position, players were divided into a more successful group and a less successful group according to team ranking in the latest regional championship and player quality within the team. Height and body mass, somatotype by the Heath-Carter method, and four tests of lower body power, speed, agility and upper body power (i.e., dependent variables) were assessed. Players in different positions differed significantly in height and all three somatotype components, but no significant differences were found in body mass, body mass index or measured physical performance variables. Players of different performance level differed significantly in both anthropometric and physical performance variables. Generally, middle blockers were taller, more ectomorphic, less mesomorphic and endomorphic, whereas liberos were shorter, less ectomorphic, more mesomorphic and endomorphic than players in other positions. More successful players in all positions had a lower body mass index, were less mesomorphic and endomorphic, and more ectomorphic than less successful players. Furthermore, more successful players showed better lower body power, speed, agility and upper body power. The results of this study can potentially provide coaches with useful indications about the use of somatotype selection and physical performance assessment for talent identification and development.

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INTRODUCTION

Volleyball is a very dynamic sport characterized by various sprints, jumps (blocking and spiking) and high-intensity court movements that occur repeatedly during competition [1]. Successful performance of these movement structures depends greatly on anthropometric and physical performance variables [2].

Differences in physical abilities and anthropometric variables between athletes of different performance level, regardless of the position, both in volleyball [3-8] and in other team sports [9,10] have been investigated in previous studies. Yet, in competitive team sports players are specialized for their specific position. Thus, research on anthropometric and physical performance variables in team sports must take into account the peculiarities of particular positions. Some research on this matter has already been done for different sports [11-14]. Players in the different positions are required to develop different skills and deal with different tactical tasks during the match [15].

Given that the selection process for certain positions in volleyball usually begins approximately at the age of 13–15 years (both European and World rankings in women start at the under 18 level [16,17]), it is important to focus on what differentiates female players of this age in terms of both anthropometric variables and physical abilities. Both anthropometric variables can change during growth and physical abilities can be improved by means of effective training, but starting from position-tuned levels can make the difference already in youth competition. If inter-positional differences are analyzed, the subject sample in a squad can be divided into very small sub-samples of 3 to 5 players. Therefore, for obvious statistical power reasons, it is important to conduct such studies on large samples of subjects, which is not always the case [12,13,18]. In this context, it is also important to determine which anthropometrical features distinguish more successful from less successful players in each playing position [19-22]. In so doing, the overall player quality in competitive athletics is sometimes defined by comparing the ranking of different teams in a competition [19,23] and sometimes by comparing individual player quality within a team (e.g., starters vs. non-starters [24]). By combining these criteria, greater sensitivity and therefore a better evaluation of the overall player quality in sports games is achieved [25]. This type of evaluation has already been successfully applied in studies investigating young female volleyball players [5-7,26-28].

It is also important to pay attention to the selection of the variables that differentiate the playing positions, as well as the players' levels in specific positions. The most frequently used anthropometric variables that meet those demands are height, mass indexes, and somatotype [20,21,23,29-33], as well as the physical performance variables of lower body power, speed, agility and upper body power [3, 4,7,8,25-27,34-36]. For instance, in a previous study of our group [28], tests of standing long jump, 20-m sprint, side steps and medicine ball supine throw were the best predictors of the physical performance determinants [37] associated with efficacy in volleyball team-play.

The aim of the present research was therefore to analyze the inter-positional and intra-positional differences in anthropometric (height, body mass, body mass index and somatotype) and physical performance variables (lower body power, speed, agility and upper body power) in a relatively large sample of young female volleyball players.

MATERIALS AND METHODS

Volleyball was an important team sport in Yugoslavia and has retained that status in at least five of the seven states originating from the former federal republic [16,17]. Croatian national teams are always well placed in both the elite and youth European and World rankings [16,17]. Therefore, due to both the high level of volleyball in this country and the subjects' availability, this research focused on local players. It represents a cross-sectional study in which Croatian young female volleyball players were assessed using ten anthropometric measures and four tests of physical performance, which represent independent variables. Based on the anthropometric variables, body mass index (BMI) was calculated as well as three somatotype components using the Heath-Carter method [38,39]. Dependent variables in this research were playing position and overall player quality. Female volleyball players were divided into five groups according to their position: setters (n=30), opposites (n=41), passer-hitters (n=54), middle blockers (n=28) and liberos (n=28) (Table 1). The overall quality of the young players was determined according to team ranking in the latest regional championship and player quality within the team (Table 2).

The subjects included 181 Croatian female volleyball players, members of 15 clubs from the Dalmatia region. This sample represents about 90% of the total population of young volleyball players from that region. The mean chronological age of players was 14.0±0.9 years, mean height 169.6±7.6 cm, body mass 57.4±9.0 kg, mean body mass index 19.9±2.4, and somatotype 4.3-2.8-3.7±1.0-1.0-1.3 (somatotype scale scores, e.g., 7–1–1 pure endo-

TABLE 1. Frequency and chronological age of young Croatian female volleyball players according to their playing positions and the estimated overall play quality.

	Setter	Opposite	Passer-hitter	Middle blocker	Libero	Total
N LS	13	24	22	11	16	86
N MS	17	17	32	17	12	95
Age (y)	14.1 ± 0.9	14.0 ± 1.0	14.1 ± 0.9	14.0 ± 0.9	14.1 ± 0.9	14.0 ± 0.9

Note: LS – less successful; MS – more successful.

TABLE 2. Individual performance level.

Regional championship ranking	Members of the national team	The most successful players in the team	Average players in the team	The least successful players in the team
1 to 4	5	5	4	3
5 to 8	5	4	3	2
9 to 12	5	3	2	1

Note: Categorization of individual player performance level. Significant examples: 1. a player belonging to the latest regional championship winning team, member of the national team and most successful player of her team is assigned a grade of 5 and therefore is assigned to the group of more successful players; 2. a player belonging to the latest regional championship last team, not member of the national team and least successful player of her team is assigned a grade of 1 and therefore is assigned to the group of less successful players; a player belonging to the latest regional championship sixth-ranked team, not member of the national team and average player of her team is assigned a grade of 3 and therefore is assigned to the group of less successful players.

morph, 1–7–1 pure mesomorph, and 1–1–7 pure ectomorph [40]). All subjects, with differences depending on their teams, had been practicing volleyball for an average of 3.1±0.7 years and, apart from their training of 3-5 times per week (4.5 to 6 hours of training; individual training sessions lasting 90-120 minutes), had been participating in weekend league matches (minimum of 22 matches during a season for each team). The number of players in each subgroup according to their position and overall player quality and their mean age are shown in Table 1. All subjects and their parents gave their informed written consent to participate in this study, which was conducted with the full accordance of all volleyball clubs as well as the expert committee of the Volleyball Association of the Dalmatia Region. The Ethical Committee of the Faculty of Kinesiology, University of Split, approved this investigation that complied with all the ethical standards for scientific investigations involving human participants (Declaration of Helsinki).

Measurements were conducted in indoor volleyball gyms from 9 to 11 am in July of 2012, immediately after the end of the youth league season. The testing was performed by two experienced (certified) specialists. The measurements were made according to the International Society for the Advancement of Kinanthropometry (ISAK) protocol [41] on the right side of the body, while the left-dominant side of the body was measured in nine volleyball players, as was originally described by Carter et al. [38] for the purposes of somatotype analysis.

After the anthropometric measurements had been taken, each athlete performed a standardized 15-minute warm-up consisting of general movements and static and dynamic stretching, as per their usual training warm-up routines, followed by four tests of motor abilities (standing long jump, 20-m sprint, side steps and medicine ball supine throw). The subjects were divided into groups and repeated each test three times (each subject repeated the test after everyone else in the group had completed the previous repetition of the test), with an adequate recovery period between tests (up to 3 minutes of rest). All four tests of motor abilities were maximum-effort tests, and, according to common practiceas they are commonly used in such a situation , the best result was used in the subsequent statistical analyses [26-28,42].

Ten anthropometric measures were used in this study: height (cm) and mass (kg); triceps, subscapular, supraspinale and calf skinfolds (mm); flexed arm and calf girth (cm); and humerus and femur breadth (cm). Such measures were made according to the guidelines outlined by ISAK [41]. A Martin Anthropometer Measuring Set and a Harpenden skinfold caliper (UK) were used. The Carter et al. equations [38] (by using the Somatotype Ver. 1.2.5 software package according to Goulding [39]) were used to calculate the anthropometric somatotypes, and BMI was calculated as the mass in kilograms divided by the square of the height in meters.

Two to three measurements were taken at each site. The average value was used in subsequent calculations when two measurements were taken, whereas the median value was used when three measurements were taken. An assistant recorded values and ensured standardization of the measurement techniques.

Skinfold sites were measured in succession to avoid experimenter bias (the complete set of variables was measured before repeating the measurement at the same site for the second and third times).

Physical performance variables were measured using four tests.

The standing long jump was applied as a test of lower body power. The subjects were instructed to jump as far as possible from an initial standing position. The jump was performed on a long jump mat [43] (Elan, Begunje, Slovenia). The distance from the starting to the landing point at the heel contact was used for further analysis. A detailed description of all the physical performance testing can be found elsewhere [26-28,40].

Speed was determined by a timed 20-m sprint. Timing began at the subject's movement out of a 2-point (base-running) stance. Sprint times were determined using a SPEED digital handheld stopwatch (Germany, error -0.04±0.24 s).

The side step test for assessing agility was measured by means of the SPEED digital stopwatch with a starting parallel straddle position with the result expressed in seconds. We acknowledge a certain lack of sprint and side step test time measurement effectiveness due to the use of a handheld stopwatch instead of a photocell-based system.

A 2-kg medicine ball throw for assessing explosive power of the arms was performed from a supine position (i.e., the subject was asked subject to throw the ball forward from a supine position as far as possible) with the result expressed in meters.

Player quality on a five-point Likert scale represents the criterion variable. A grade of 1 to 5 was assigned to each player regarding two criteria (Table 2) [5]:

1. Team ranking in the latest regional championship (i.e., team sport-specific objective criterion). All teams participated in the Dalmatia regional championship and, based on their ranking in the championship, were classified into three categories (1st to 4th place; 5th to 8th place; 9th to 12th place).
2. Player quality within the team (as assessed by the team coaches, i.e., team sport-expert subjective criterion). Each coach divided the players of her/his team into three groups (the most successful – the most efficient players; average – other starters and non-starters, who contribute to game quality; and the least successful – non-starters who very rarely or never enter the game because of their poor technical/tactical qualities).

With the purpose of providing a sufficient number of entities within the sub-samples of female volleyball players, all players who were assigned grades of 1 to 3 were assigned to the less successful group, while all players who were assigned grades 4 and 5 were assigned to the group of more successful players.

Descriptive variables of the anthropometric and physical performance demonstrated no significant deviation from the normal distribution, so parametric methods could be applied in further statistical data analyses.

Statistical comparisons between less successful and more successful players in each position were performed using an independent t-test. Comparisons between positions (middle blockers, opposite hitters, passer-hitters, setters, and liberos) were performed with a 1-way analysis of variance (ANOVA). To assess the variability of the physical performance variables measures, we calculated their coefficient of variation (CV=SD/mean, % [44]).

In the event of a significant "F" ratio, Tukey HSD post-hoc tests were used for pairwise comparisons. A criterion alpha level of $P \le 0.05$ was used to determine statistical significance. All data are reported as the mean ± SD.

RESULTS

Table 3 illustrates the inter-positional differences observed in the anthropometric and physical performance variables. Young female volleyball players in various playing positions differed significantly in height and all three somatotype components, whereas no significant differences were found in body mass, body mass index and the measured physical performance variables. Their variability was from low to intermediate (CV 11%, 3%, 10%, 15%, for standing long jump, 20-m sprint, side steps and medicine ball supine throw, respectively). Libero players were the shortest, least ectomorphic, and most mesomorphic and endomorphic, and middle blockers were the tallest, most

TABLE 3. Inter-positional differences of young female volleyball players in anthropometric and physical performance variables.

Variable	Setter N=30	Opposite N=41	Passer-hitter N=54	Middle blocker N=28	Libero N=28	F
Body height (cm)	166.1 ± 6.2°‡	169.6 ± 6.8‡†	171.6 ± 6.1*†	174.9 ± 8.5*§†	163.8 ± 6.2§°‡	12.805#
Body mass (kg)	54.4 ± 6.6	58.3 ± 9.4	58.0 ± 8.3	58.6 ± 11.5	56.8 ± 9.1	0.995
BMI ($kg \cdot m^{-2}$)	19.8 ± 2.1	19.8 ± 2.6	19.7 ± 2.3	20.3 ± 2.9	20.1 ± 1.8	1.377
Endomorph c.	4.2 ± 1.0†	4.5 ± 1.1‡	4.2 ± 0.9‡†	3.8 ± 0.9§° †	4.9 ± 1.1*°‡	5.495#
Mesomorph c.	3.0 ± 0.8‡†	2.9 ± 1.0‡†	2.5 ± 0.9†	2.1 ± 1.0*§†	3.8 ± 1.0*§°‡	12.312#
Ectomorph c.	3.5 ± 1.0‡	3.5 ± 1.2‡	4.0 ± 1.0†	4.6 ± 1.4*§†	2.8 ± 1.2°‡	9.358#
Standing long jump (cm)	180.4 ± 16.1	178.7 ± 20.3	177.4 ± 19.1	173. 9 ± 23.6	173.5 ± 18.9	1.117
20-m sprint (s)	3.7 ± 0.2	3.7 ± 0.3	3.7 ± 0.3	3.8 ± 0.3	3.7 ± 0. 2	0.854
Side steps (s)	9.7 ± 0.7	9.9 ± 1.0	9.8 ± 0.6	9.9 ± 0.6	9.7 ± 0.8	0.887
Medicine ball throw (m)	5.9 ± 0.7	5.9 ± 0.8	6.0 ± 0.9	6.0 ± 0.9	5.7 ± 1.0	1.095

Note: Fisher value "F" and statistically "#" significant inter-positional differences of variables $P \le 0.01$; Tukey HSD post-hoc tests, $P \le 0.05$; - significant differences in relation to setters; § - significant differences in relation to opposites; ° - significant differences in relation to passer-hitters; ‡ - significant differences in relation to middle blockers; † - significant differences in relation to liberos). All variables are reported as mean ± standard deviation.

TABLE 4. Intra-positional differences of young female volleyball players in anthropometric and physical performance variables.

Variables	Criterion of quality	Setter LS=13 MS=17	Opposite LS=24 MS=17	Passer-hitter LS=22 MS=32	Middle blocker LS=11 MS=17	Libero LS=16 MS=12
Body height (cm)	LS	162.0 ± 5.2	167.6 ± 6.8	169.0 ± 5.5	173.7 ± 6.9	164.2 ± 6.9
	MS	169.2 ± 5.1*	172.4 ± 6.0*	172.7 ± 6.4*	175.8 ± 9.6	163.4 ± 5.4
Body mass (kg)	LS	54.7 ± 7.0	59.25 ± 10.6	59.3 ± 9.2	61.5 ± 10.8	60.0 ± 7.9
	MS	54.1 ± 5.6	57.1 ± 7.6	57.2 ± 7.8	56.8 ± 11.8*	52.6 ± 9.1*
BMI ($kg \cdot m^{-2}$)	LS	20.7 ± 1.8	20.5 ± 2.9	19.6 ± 2.2	21.2 ± 2.9	22.3 ± 2.6
	MS	18.8 ± 2.0*	18.7 ± 1.7*	19.0 ± 2.0*	18.3 ± 2.2*	20.0 ± 1.1*
Endomorph c.	LS	4.7 ± 0.8	4.8 ± 1.1	4.7 ± 1.1	4.4 ± 0.9	5.4 ± 1.1
	MS	3.7 ± 0.9*	4.1 ± 1.0*	4.0 ± 0.7*	3.4 ± 0.7*	4.6 ± 0.9*
Mesomorph c.	LS	3.5 ± 0.8	3.3 ± 1.0	2.8 ± 1.0	2.7 ± 1.2	4.2 ± 1.0
	MS	2.6 ± 0.7*	2.4 ± 0.8*	2.3 ± 0.8*	1.8 ± 0.8*	3.2 ± 0.7*
Ectomorph c.	LS	2.7 ± 0.8	3.0 ± 1.2	3.5 ± 1.1	3.8 ± 1.1	2.2 ± 1.0
	MS	4.2 ± 0.7*	4.2 ± 0.9*	4.3 ± 0.9*	5.1 ± 1.3*	3.5 ± 1.1+
Standing long jump (cm)	LS	169.8 ± 11.5	174.7 ± 22.2	170.0 ± 15.6	167.7 ± 23.0	170.8 ± 18.4
	MS	188.6 ± 14.3*	184.2 ± 16.3*	182.6 ± 19.8*	177.9 ± 23.9*	179.2 ± 19.3*
20-m sprint (s)	LS	3.8 ± 0.1	3.8 ± 0.3	3.7 ± 0.3	4.0 ± 0.2	3.8 ± 0.2
	MS	3.6 ± 0.2*	3.7 ± 0.2*	3.6 ± 0.2*	3.7 ± 0.2*	3.7 ± 0.2*
Side steps (s)	LS	10.0 ± 0.6	10.0 ± 1.1	10.0 ± 0.5	9.9 ± 0.7	10.0 ± 0.7
	MS	9.5 ± 0.6*	9.6 ± 0.9*	9.5 ± 0.7*	9.4 ± 0.7*	9.4 ± 0.9*
Medicine ball throw (m)	LS	5.7 ± 0.7	5.7 ± 0.9	5.8 ± 0.8	6.0 ± 0.9	5.7 ± 1.0
	MS	6.1 ± 0.8*	6.2 ± 0.7*	6.2 ± 1.0*	6.0 ± 1.0	5.7 ± 1.0

Note: N=181, *- statistically significant intra-positional differences between less successful and more successful young female volleyball players in the analyzed variables, independent t-test, $P \le 0.05$). All variables are reported as mean ± standard deviation.

ectomorphic, and least mesomorphic and endomorphic in comparison to other positions.

Regarding somatotype categories, middle blockers fall into the endo-ectomorph, passer-hitters into the ectomorph-endomorph, liberos into the meso-endomorph, and setters and opposites into the ecto-endomorph category.

Table 4 illustrates the intra-positional differences in the analyzed variables between less successful and more successful female volleyball players. More successful setters, opposites and passer-hitters differed significantly from less successful players in these positions in all variables except body mass. Regarding somatotype, more successful players were much taller, with a considerably lower body mass index. They were more ectomorphic and less endomorphic and less mesomorphic. In all of the analyzed physical performance variables, more successful setters, opposites and passer-hitters had significantly better results in comparison to the less successful players of these positions. More successful players playing in middle blocker and libero positions differed significantly from less successful players in all variables except for height and medicine ball supine throw. More successful players also had much lower body mass, had a lower body mass index, and were less endomorphic and mesomorphic and more ectomorphic. In addition, they demonstrated better jumping, sprinting and agility abilities.

DISCUSSION

The main goal of this study was to determine intra-positional and inter-positional differences in young female volleyball players (under 15 age group) during a period of their career in which specialization according to playing position is applied for the first time and the differences within particular positions between more successful and less successful players start to be decisive as well. Investigated differences regarded anthropometric and physical performance variables. Young female volleyball players in various playing positions differed significantly in height and all three somatotype components, whereas no significant differences were found in body mass, body mass index or the measured physical performance variables. For inter-level results, the successful players usually had significantly greater height and lower BMI with higher physical performances.

Usually, the selection of young female volleyball players for specific playing positions in the analyzed clubs was mostly conducted according to the body shape (height and somatotype components) and not to the physical performance variables. Height cannot be affected by training [45] and, considering its positive correlation with maximum jump heights, is also an important requirement for successful performance in those playing positions that require frequent spiking and blocking. In modern volleyball, teams that dominate the game above the net win most often, and one of the most important requirements is the selection of tall players for playing positions particularly characterized by above-the-net playing.

Given that libero players do not play in the front row and are not allowed to spike or block and that setters also spike very seldom, players in those positions were the shortest, as expected. A low centre of mass is particularly important in playing low balls during landings for serve receive and field defence, which are the main tasks of libero players [1]. A low centre of mass is also an advantage for the sudden changes of direction that are often performed by setters [1].

The purpose of the investigation on somatotypes is to offer a reference for talent identification, which aims to identify and foresee the development tendency of the athlete's height, body mass, fat, muscles and bones over different growth stages as well as to understand the specific anthropometric features required for different sports [10]. Players in a middle blocker position are characterized by a dominant ectomorph somatotype component, which is specific for tall, slim people with long extremities (limbs). For volleyball, which is not a contact sport, huge muscle mass is not necessary for successful performance in any particular position. Being too heavy may even impair repeated jumping performance [22]. Therefore, low to moderate values of the mesomorph somatotype component, indicating a gracile skeleton, are expected, especially for the middle blocker position. Given that volleyball is characterized by frequent jumps and fast changes of direction, excess subcutaneous fat tissue is not recommended. In research studies on samples of elite female senior players [20,33], the endomorph somatotype component of players in all positions was lower than 4. This finding explains why average values of the endomorph component, recorded particularly in libero and opposite players, can be considered a limiting factor in reaching their maximum potential, but also represents an additional risk factor for injuries to the lower back or knee during frequent landings and sudden changes of speed and direction [28]. Such moves are very frequent in volleyball [22], so the reduction of subcutaneous fat tissue in some players should be pursued by means of proper diet and physical activity.

The greatest intra-positional differences in height were found in the setter position. This is generally the position in which, even at elite level, there are great individual differences in height. It can be assumed that, at club level, Croatian coaches do not have available an adequate number of players taller than the average height from each single age group, so taller players are employed primarily as middle blockers and then as passer-hitters and opposite hitters. Yet, some coaches, because of the importance of this position, intentionally choose tall players with good motor abilities and leadership for the setter position. In so doing, they are aware that this will have a short-term effect of worsening the attacking quality of the team for the specific age group. Yet, they also know that such a choice can make a long-term contribution to the game quality of the senior team.

At first glance, it is surprising that more successful middle hitters are not significantly taller than less successful ones. Height is most likely the main requirement for selection of players for this position, so players who play in this position, regardless of their efficacy, are taller than average. This finding is supported by the fact that less successful players in the middle blocker position are, on average, taller than more successful players in other playing positions.

Due to the specific task of the libero player, height does not represent an advantage for playing in this position. This observation could also explain the absence of significant differences in height between more successful and less successful libero players. The absence of differences in body mass between more successful and less successful setters, opposites and passer-hitters is a consequence of the significantly greater height of more successful players in those positions The absence of differences in height between more successful and less successful middle blocker and libero players is a consequence of the significantly lower body mass of the more successful players in those positions. Significantly lower values of the BMI in more successful players in comparison to less successful players in all playing positions confirm the previous statement. Newton's second law states that it is harder to put into motion, stop or change the direction of bodies of greater mass; acceleration of a body is inversely proportional to its mass; and bodies of greater mass are affected by a stronger gravitational force. This means that, in a volleyball match, players with higher body mass indices move more slowly on the court and jump less in comparison to their lower-body-mass-index teammates of equal strength and skill [22].

Intra-positional differences in particular somatotype components can be explained in the same way. More successful players, in all positions except for libero, are characterized by the highest values of the ectomorph somatotype component, whereas the endomorph somatotype component is dominant in less successful players. The values of the somatotype components in more successful players in the present research are similar to those in young members of the Brazil Women's National Team (3.1-2.2-3.9 [46]), as well as those of candidates for the Turkey Women's Youth National Volleyball Team (3.4-2.1-4.5 [29]). The ectomorph somatotype component is also prevalent in elite Chinese senior women volleyball players, (3.7-2.9-4.0 [47]), especially in the positions of middle blockers and opposites. This finding confirms the conclusions made by Papadopoulou et al. [36] indicating that the somatotype of top young female athletes does not differ significantly from the somatotype of top adult athletes. The same authors claim that heredity represents an important determinant of somatotypes and recommend that values of somatotype of young female volleyball players should be taken into account in the selection process, which is fully confirmed by the present study in young Croatian female players. Given that athletes' somatotypes do not change from youth to adulthood, some talent identification based on somatotype selection seems reasonable.

It can be concluded that more successful young female volleyball players base their superior play on a lower body mass index, less prominent endomorph and mesomorph somatotype components and a more prominent ectomorph component compared to less successful players in similar positions. More successful setters, passer-hitters and opposites also dominate in height, in comparison to less successful players in the same positions, whereas more successful middle blockers and liberos have a significantly lower body mass.

Jumping, sprinting and agility abilities underlie the performance quality of all technical-tactical elements during a volleyball match [48,49]. These abilities enable good timing for the spike and the block, as well as higher contact with the ball above the net. This evaluation could also explain the significant differences in those physical performance differences found between more successful and less successful young female volleyball players in all playing positions. Upper body explosive power has been shown to be particularly relevant mainly during forceful spiking and jump serves [26]. Therefore, intra-positional differences regarding this ability in passer-hitters and opposites seem logical, because most successful players in these positions often use forceful jump serves as well as spikes. As opposed to passer-hitters and opposites, middle blockers' spikes put more emphasis on precision as opposed to power. Therefore, it is evident that coaches should select very tall, slim players with good lower body power and agility to play in this position from this age group, and coaches should not consider upper body power to be a limiting factor. Setters rarely spike during a match, so from this point of view, the authors did not expect to find significant differences regarding upper body power between more successful and less successful players in this position. Actually, more successful setters were found to be significantly better than their less successful counterparts in the medicine ball throw (Table 4). The overhead pass is a fundamental skill performed by setters during almost every match point to organize the attack. Adequate upper body power is necessary for young players so that their passing precision is not impaired during repeated setting the spike, even at great distance.

The observed inter-positional differences in height and somatotype of young female volleyball players indicate that the unified talent-selection model often used in practice is not an adequate solution. Selection for particular playing positions should be done by considering body size and shape of young female volleyball players. The importance of height was confirmed, especially for the middle-blocker position, in which all players, regardless of their efficacy, are taller than average. Height is important for success in all of the other playing positions, except libero. Less successful female volleyball players in all playing positions are characterized by a higher body mass index and dominance of the endomorph somatotype component. Therefore, attention should be paid to a proper diet for players with excess subcutaneous fat tissue. Within all playing positions, more successful players dominate in lower body power, speed and agility, while more successful setters, passer-hitters and opposites dominate in upper body power as well. This finding confirms that those physical performance variables must be taken into consideration in the process of selection of players for particular positions. Additionally, attention should be paid to the development of those abilities during the training process. This study focused on females, but further research should regard males as well. We acknowledge that successful volleyball playing is determined by several additional factors, other than optimum anthropometric and physical performance variables values (e.g., training quantity and quality, perceptive, cognitive and technical-tactical skills, and mental qualities, amongst others). All the coaches of the studied teams in the present study regularly attended annual coaching seminars organized by the Croatian Volleyball Federation. At these seminars it is discussed what type of training is required for younger age categories. Also, all coaches in the Dalmatia region communicate with each other and often coach friendly and competitive matches (personal observations). Therefore, it can be assumed that there are a number of similarities in the training methods of these teams. However, there is no doubt that every coach adapts planning and programming of the training process to the characteristics of his team and her/his own coaching philosophy. Therefore, there is still a potential effect of training differences on the observed reported data.

The information provided by this study has the potential to allow coaches and athletes to identify objective physical and performance data specific for young players, for the purposes of evaluation and player development.

CONCLUSIONS

This study provides an original position-specific description of the anthropometric and physical performance variables of young female volleyball players. The obtained results provide a clearer insight into the inter-positional and intra-positional differences in the investigated variables. Players in different positions differ in some anthropometric variables but not in physical performance ones. Players of different performance levels differ in both anthropometric and physical performance variables.

It can be assumed that the differences in quantity and quality of training among the teams probably affect, at least to some extent, their competitive efficacy. Using the results provided here, volleyball coaches would be able to choose their young players for their most appropriate playing positions according to their anthropometric and physical performance variables. This study provides reference data that could be used in designing training programs to assist young volleyball athletes with the development of position-specific training goals.

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