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Somatotypes of Top Croatian Male Volleyball Players

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Abstract

Situational efficiency of volleyball players depends on many factors, including specific ones in the area of morphology. The specialization of playing roles implies the performance of specific motor tasks, and therefore a specific combination of morphological factors necessary for the player's efficiency. This study aimed to determine the somatotypes of groups of top-level volleyball players divided according to their playing role. The research was conducted on 40 (body height 192.22±8.58 cm, body weight 86.93±11.22 kg, age 24.18±4.97 years) male volleyball players from the Croatian A1 volleyball league. According to the playing role, 10 setters (body height 191.21±6.39 cm, body weight 84.12±8.76 kg, age 24.12±6.77 years), 10 middle blockers (body height 199.97±4.41 cm, body weight 94.82±6.67 kg, age 26.05±26.05 years), 10 liberos (body height 181.71±5.71 cm, body weight 74.97.21±5.59 kg, age 22.67±2.88 years) and 10 outside hitters (body height 196.06±4.34 cm, body weight 93.80±10.29 kg, age 23.89±5.53 years). Heath-Carter method was used for the somatotype determination. A statistically significant difference between the groups was detected in Body height, Body weight, Flexed arm girth circumference, Flexed calf girth circumference and Calf skinfold. The determined somatotypes for setters (2.8 - 3.8 - 3.4) and middle blockers (2.3 - 3.8 - 3.6) are mesomorph-ectomorph, and liberos (2.4 - 4.6 - 3.0) and outside hitters (2.5 - 4.3 - 3.1) are ecto-mesomorph. The results are in line with previous research. This confirms the importance of the longitudinal dimensionality of the skeleton in volleyball. In the future, we can expect the growth of the ectomorph component, with a stagnation or slight increase in the mesomorph component of the somatotype in top level volleyball.

Keywords: *volleyball, morphology, Heath-Carter, somatogram, playing roles*

Introduction

Due to its simplicity and variability, volleyball is one of the most popular team sports, and so is the FIVB (FIVB, 2023) federation one with the largest number of members (222). Considering the specificity of volleyball ("game on the net"), certain factors of the morphological area are particularly important for player selection, both in younger age categories, as well as at the top level (Đurković, 2009). Specialization of playing roles implies the performance of specific motor tasks, and therefore also a specific combination of morphological factors required for players' efficiency (Marques, Van den Tillaar, Gabbett, Reis & Gonzalez-Badillo, 2009; Palao, Manazares & Valades, 2014). Generally, a player's body height is of significant relevance for playing professionally in this sport, apart from the role of libero. Upon studying morphological characteristics among groups with different playing roles (setters, middle blockers, outside hitters and libero players), the results can present information on the tendency of a certain playing role towards a specific body constitution type (Palao et al., 2014). Previous research on a sample of senior male volleyball players confirmed the hypothesis on the presence of four latent dimensions of the morphological area (Momirović, 1966; Strahonja & Matković, 1983; Đurković, Marelić & Rešetar, 2011), which were also confirmed on a sample of young and active persons (Momirović, Medved & Horvat, 1969; Medved, 1987; Marković, 2004). The factor of longitudinal dimensionality of the skeleton (which is defined by body height, arm span and the length of the arms, legs, and feet) is registered as the one in which the groups of players significantly differ (Đurković, Marelić & Rešetar, 2012).

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One of the systems for body constitution assessment is the Heath-Carter method (Carter & Heath, 1990), where the somatotype is defined by using three indexes – indexes of the endomorph, mesomorph, and ectomorph component. The endomorph component is an indicator of subcutaneous fat tissue presence, the mesomorph of joint robustness and proportion of lean mass, while the ectomorph point to the elongation of the body. Considering the aforementioned, it can be assumed that male volleyball players who were singled out in the process of selection as higher athletes shall be dominant in the last component. The tallest players, middle blockers, are also the heaviest players (Marques et al., 2009), which can affect the results of the ectomorph component. The setters, who are tall, however do not have the need for large muscle mass, i.e., body robustness, can demonstrate characteristics of an asthenic constitution. Spikers, due to the need for fast spikes and constant displays of maximum force through jumps and spikes, have the most pronounced results in the mesomorph component, as well as the libero because of his quick reactions, and agile and explosive movements (Petroski et al., 2013). In top-level volleyball (Janković, Đurković & Rešetar, 2009) the following playing roles are recognized: setters, middle blockers (central players), liberos, opposite (diagonal) hitters and receiver-attackers. Especially interesting are the results of longitudinal studies of somatotypes in top-level male volleyball players selected into national teams (Petroski et al., 2013 – Brazil / 11 years; Carvajal & Serviat Hung, 2014 – Cuba / 40 years) where there were changes registered in terms of a reduction of subcutaneous fat tissue of the examinees, however, also in terms of constant increase of the ectomorph component which is manifested through the increase of the average body height of the competitors of approximately 1 cm per decade, which shows us that taller volleyball players with less subcutaneous fat tissue passed the selection process, however, with constant, and even somewhat increased results in the mesomorph component. The results obtained on a sample of top-level club male volleyball players (Gualdi-Russo & Zaccagni, 2001; Toselli & Campa, 2018) who compete in the world's strongest volleyball league – the Italian league, confirm the fact that better quality players are taller and have a lower percentage of subcutaneous fat tissue, identically as the ones conducted on a sample of Greek first-league volleyball players (Giannopoulos, Vagenas, Noutsos, Barzouka & Beregles, 2017), where in addition to the previously mentioned trends, there was also a significantly greater body mass of quality volleyball players which is related to active muscle mass, as well as to a lower endomorph component. Greater body mass of individual playing roles is related to body height, and therefore taller volleyball players are also heavier (Marques et al., 2009). The results of a research by D'isanto, Di Tore and Altavilla (2018) confirmed a significant and high correlation between morphological indicators and the height of reach in volleyball players tested by using the Vertec system, which is relevant, as the height of reach is very important for the efficiency of the technical-tactical element of spike, which is used to win the greatest number of points in volleyball (Bellendier, 2003; Marelić, Rešetar, Zadražnik & Đurković, 2005; Đurković, Ban & Krmpotić, 2021). Challoumas and Artemiou (2018) determined a statistically significant, but negative correlation between the percentage of subcutaneous fat tissue and the speed of the volleyball spike. Although there are certain studies related to morphology and volleyball in Croatia, this is the first one that has top senior volleyball players as respondents. In addition to the somatotype of the entire sample, the somatotypes for each playing role will be determined. This information can help coaches as model values for selection processes in the future. The aim of this study is to determine the somatotypes of different groups of male volleyball players, depending on their playing role (setter, middle blocker, libero, outside hitter). In addition, it will be verified if there is a statistically significant difference between the groups of volleyball players in 10 anthropometric morphological measurements in accordance with the Heath-Carter method for assessing somatotypes.

Methods

Sample of examinees

The research was conducted on a sample of forty senior male volleyball players (body height 192.22±8.58 cm, body weight 86.93±11.22 kg, age 24.18±4.97 years) all members of A1 league volleyball clubs. The tested volleyball players compete at the highest level in Croatia, and most of them were members of senior national team in some part of their career. In the presentation of the obtained results and data processing, the players are distributed into four groups according to their roles: 10 setters (body height 191.21±6.39 cm, body weight 84.12±8.76 kg, age 24.12±6.77 years), 10 middle blockers (body height 199.97±4.41 cm, body weight 94.82±6.67 kg, age 26.05±26.05 years), 10 liberos (body height 181.71±5.71 cm, body weight 74.97.21±5.59 kg, age 22.67±2.88 years) and 10 outside hitters (body height 196.06±4.34 cm, body weight 93.80±10.29 kg, age 23.89±5.53 years). For this study, the roles of the opposite (diagonal) hitter and receiver-attacker have been combined into a group of outside hitters, as it was done in several previous research (Paz et al., 2017; Bisch et al., 2020; Rush, Littlefield, McInnis & Donahue, 2022). All measurements of the volleyball players were conducted at the Faculty of Kinesiology University of Zagreb. The research related to human use was complied with all the relevant national regulations and institutional policies, has followed the tenets of the declaration of Helsinki and has been approved by the research Ethics Committee of the Faculty of Kinesiology, University of Zagreb, Croatia (approval No.22./2023. as of March 13, 2023).

Measurements procedure

For the purpose of this research, 10 morphological measurements were estimated for determining the somatotype in accordance with the Heath-Carter method: Body height, Body weight, Humerus breadth diameter, Femur breadth diameter, Flexed arm girth circumference, Flexed calf girth circumference, Triceps skinfold, Subscapular skinfold, Supraspinal skinfold and Calf skinfold. The measurements were performed by qualified measurers who are members and external associates of the Sports Diagnostics Centre at the Faculty of Kinesiology in Zagreb. All participants gave written consent. The measurements were taken according to the anthropometric protocol of the International Society for the Advancement of Kinanthropometry – ISAK (Stewart, Marfell-Jones, Olds & De Ridder, 2011). The somatotypes were calculated and categorized by using the Heath-Carter method for assessing somatotypes.

Statistical analysis

The collected data was entered and processed by using the

statistical programme Statistical package Statistica, version 13.5.0.17 (TIBCO Software Inc., Palo Alto, CA, USA). The basic descriptive parameters were calculated for assessing the normality of distribution by using the Kolmogorov-Smirnov test. For verifying the statistical significance of the measured variables among the groups of tested volleyball players the Kruskal-Wallis test was used, whereas for further analysis of the detected significantly different results the Mann-Whitney U post-hoc test with the Bonferroni correction was used, and a p-level of 95% was applied.

Results

The normality of distribution was verified with the Kolmogorov-Smirnov test. The results of the variables for the assessment of skin folds were statistically significantly deviated from normal distribution, and therefore non-parametric methods were chosen for the continuation of statistical data processing. The descriptive indicators of the overall sample (AM±SD), as well as separately for each playing role are presented in Table 1. This table also shows the results of the Kruskal-Wallis test with the Mann-Whitney U post-hoc test and the Bonferroni correction.

Table 1. Results of Kruskal-Wallis test with the Mann-Whitney U post-hoc test and the Bonferroni correction

Variables	Total	Setters	Middle blockers	Liberos	Outside hitters	p
	(n=40)	(n=10)	(n=10)	(n=10)	(n=10)	
Body height (cm)	192.22±8.58	191.21 ± 6.39ml	199.97 ± 4.41sl	181.71 ±5.71smo	196.06 ± 4.34sl	0.00
Body weight (kg)	86.93±11.22	84.12 ± 8.76ml	94.82 ± 6.67sl	74.97 ± 5.59smo	93.80 ± 10.29l	0.00
Humerus breadth diameter (cm)	7.30±0.36	7.25 ± 0.53	7.37 ± 0.29	7.12 ± 0.19	7.45 ± 0.29	0.10
Femur breadth diameter (cm)	10.17±0.55	10.08 ± 0.64	10.46 ± 0.43	9.83 ± 0.46	10.29 ± 0.48	0.06
Flexed arm girth circumference (cm)	34.42±2.15	33.92 ± 1.65	35.12 ± 2.37l	33.08 ± 1.20m	35.55 ± 2.46	0.04
Flexed calf girth circumference (cm)	38.72±2.42	37.29 ± 1.76mo	40.56 ± 1.64sl	36.61 ± 1.52m	40.40 ± 1.77sl	0.00
Triceps skinfold (mm)	9.46±3.39	10.22 ± 3.05	9.57 ± 2.63	8.24 ± 2.38	9.82 ± 5.06	0.39
Subscapular skinfold (mm)	10.67±2.67	11.37 ± 3.83	10.26 ± 1.75	10.18 ± 1.64	10.87 ± 3.06	0.99
Supraspinal skinfold (mm)	8.95±4.50	10.68 ± 5.15	8.23 ± 2.64	7.60 ± 4.89	9.29 ± 4.95	0.11
Calf skinfold (mm)	7.30±2.67	8.70 ± 1.75m	6.87 ± 2.00s	5.87 ± 1.69s	7.73 ± 4.03	0.03

Significantly different from ssetters, mmiddle blockers, lliberos, ooutside hitters

The Kruskal-Wallis test revealed a statistically significant difference in 5 out of the 10 measured variables: Body height, Body weight, Flexed arm girth circumference, Flexed calf girth circumference and Calf skinfold. The additional Mann Whitney post-hoc test with the Bonferroni correction (as this was an analysis between 4 different groups, the level of statistical significance was set at p=0.05/4=0.0125) was used for analysis of the variables for which the Kruskal-Wallis test registered statistically significant differences. Upon analysis of the Body height variable, a statistically significant difference was recorded between setters and middle blockers (U=10.00, z=-3.02, p=0.00). The average height of middle blockers is 199.97±4.41, while of setters it is 191.12±6.39. Significant difference exists between libero players and setters (U=8.00, z=-3.17, p=0.00), liberos and middle blockers (U=0.00, z=-3.78, p=0.0), as well as between liberos and outside hitters (U=0.00, z=-3.78, p=0.00). The average height of libero players is 181.71±5.71 cm, whereas the heights of setters, middle blockers and outside hitters are respectively 191.12±6.39 cm, 199.97±4.41 cm and 196.06±4.34 cm. By analysing the variable of Body weight, a statistically significant difference was found between setters and middle blockers (U=13.00, z=-2.80, p=0.01). The average body weight for the group of setters is 84.12±8.76 kg, while for the middle blockers it is 94.82±6.67 kg. Significant difference exists between middle blockers and libero players (U=3.00, z=-3.55, p=0.00), with a considerably lower average body weight of libero players 74.97±5.39 kg, as well as between liberos and outside hitters whose average weight is 93.80±10.29 kg (U=3.00, z=-3.55, p=0.00). In the analysis of the variable Flexed arm girth circumference the only recorded significant difference was found between the groups of libero players and outside hitters (U=16.00, z=-2.58, p=0.01). A smaller average value of 33.08±1.20 cm was measured for libero players, as opposed to the group of outside hitters with the average of 35.55±2.46 cm. Upon analysis of the variable Flexed calf girth circumference a significant difference was found between setters and middle blockers (U=8.00, z=-3.18, p=0.00), as well as between setters and outside hitters (U=10.50, z=-2.99, p=0.00). Furthermore, a significant difference was recorded between the groups of libero players and middle blockers (U=2.50, z=-3.60, p=0.00) and between liberos and outside hitters (U=4.00, z=-3.48, p=0.00). The analysis of the variable Calf skinfold showed a significant difference between the groups of setters and libero players (U=14.00, z=-2.72, p=0.01). The group of setters showed higher average values of 8.70±1.75 mm, while the group of libero players showed values of 5.87±1.69 mm. The calculated somatotypes of the groups of players are presented in Table 2. Considering the obtained data, the conclusion can be made that the somatotypes of setters (2.8 - 3.8 - 3.4) and middle blockers (2.3 - 3.8 - 3.6) are mesomorph-ectomorphs, while of libero players (2.4 - 4.6 - 3.0) and outside hitters (2.5 - 4.3 - 3.1) are ectomorph-mesomorph.

The results of somatotypes for groups of volleyball players calculated by using the Heath-Carter method on the somatogram are presented in Figure 1.

Table 2. Somatotypes of tested volleyball players

Somatotype	Total	Setters	Middle blockers	Liberos	Outside hitters
	(n=40)	(n=10)	(n=10)	(n=10)	(n=10)
Endomorphy	2.5	2.8	2.3	2.4	2.5
Mesomorphy	4.16	3.8	3.8	4.6	4.3
Ectomorphy	3.28	3.4	3.6	3	3.1

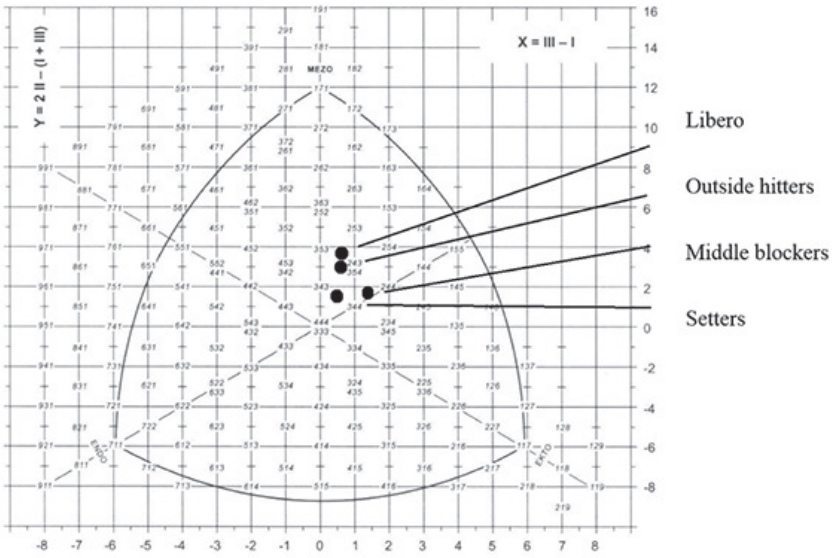

FIGURE 1. Somatogram of volleyball players according to playing roles

Discussion

Upon analysis of the Body height variable, a statistically significant difference was recorded between setters and middle blockers. The longitudinal dimensionality of the skeleton is a key morphological factor for middle blockers (Janković et al., 2009), as their primary task is in the block phase, as well as attacks by quickly setting balls (so-called first tempo attack). Defensive plays of middle blockers are very limited, and that is to the rotation in which they serve. Although it is preferable for setters to also be taller because they participate in plays on the net (a taller setter can be more efficient while blocking and attacking – most often with the so-called second touch, i.e., dumping the ball, however also sometimes with a spike), the focus of their performance nevertheless remains on tactically justified and precise sets (Janković & Marelić, 2003) for the hitters. Significant difference between the mentioned two playing roles in this variable is also often found during other research on samples of top-level senior male volleyball players (Grgantov, 2002; Marques et al., 2009; Sattler, Sekulić, Hadžić, Uljević, & Dervišević, 2012; Palao et al., 2014). Significant difference was also determined between the liberos and all the other playing roles (Đurković, Marelić, & Zekić, 2020). In the Body height variable, there is a statistically significant difference between libero players and setters, liberos and middle blockers, as well as between liberos and outside hitters. Libero players do not participate in plays on the net, and therefore body height is not a crucial factor for being a successful player in that position. Their primary role is service reception, defending the field and covering the attackers, however, more and more often also setting the ball.

By analysing the variable of Body weight, a significant difference was found between setters and middle blockers. Identical as for the variable of Body height, this variable also indicated a statistically significant difference. The reason for this is in the correlation between body height and body weight, as taller players are generally also heavier (Ciesla et al., 2015). The same conclusion can also be made in relation to the difference between middle blockers and libero players, and outside hitters and libero players, with a considerably lower average body weight of libero players.

The only recorded significant difference in the variable Flexed arm girth circumference was found between the groups of libero players and outside hitters. A smaller average value was measured for libero players, as opposed to the group of outside hitters. The upper arm circumference is partially related to the cross-section of upper arm muscles (Eaton-Evans, 2013). The probable cause for this is the high number of repetitions of the spike and serve techniques which are performed by outside hitters. The mentioned difference in fact shows the specificities of these two playing roles – outside hitters, whose priority is to perform strong and efficient spikes and serves, and libero players, who according to the rules of volleyball are not allowed to serve and spike.

Upon analysis of the variable Flexed calf girth circumference a significant difference was found between setters and middle blockers, as well as between setters and outside hitters. A potential reason for this lies in the specific performance of middle blockers and outside hitters, as they generally perform jumps with maximum intensity, i.e., maximum engagement of muscle groups (particularly in the phases of attack spike and counter-attack spike). Although according to some research setters perform the highest number of jumps during games (Fontani, Ciccarone, & Giulianini, 2000; Bahr & Bahr, 2014), most of them are performed in the preparatory phase for setting and thus most often do not de-

mand maximum intensity. Furthermore, a significant difference was recorded between the groups of libero players and middle blockers, and between liberos and outside hitters. A likely reason for this significant difference in the mentioned variable is the specificity of tasks which the two playing roles perform during a volleyball match. During trainings and games, middle blockers and outside hitters execute many vertical rebounds, whereas libero players do not. The analysis of the variable Calf skinfold showed a significant difference between the groups of setters and libero players. The group of setters showed higher average values than liberos. The possible reason for this is in the fact that certain setters were older (three of them are in their late thirties). Even though they were not in their top-level sports form (which was potentially also manifested in the results of this skinfold), they played at a very high level and were selected for the team in their older veteran age because of some other advantages – experience, calmness, responsibility, and tactical decision-making. Similar data was also found by Marques and Marinho (2009) and Palao et al. (2014) on a sample of senior male volleyball players. The variables for assessing the skinfolds provide information on the proportion of subcutaneous fat tissue and thus define endomorphy (Đurković, 2009). In volleyball, subcutaneous fat tissue should be reduced to a minimum due to the need for speed, agility and jumping (Nikolaidis, 2013), however also as prevention from chronic injuries because of a high number of landings (Vanderlei et al., 2013). This feature is independent of other morphological characteristics, and it shows the highest result variability in Table 1. Regardless of a higher proportion of fat tissue, technical-tactical maturity and player experience can be an advantage in the selection of players who are in poorer sports form in relation to the team. A confirmation of this lies in the players who in their older veteran age play at a very high level, which is also certified by different research (Marques & Marinho, 2009; Palao et al., 2014).

The variables that show a low variability of results are diameters and circumferences which define the mesomorph component of the somatotype. Within each playing role, as well as within the overall sample, very similar results were found with low variations of standard deviation. Mesomorphy is particularly pronounced in playing roles of outside hitters and libero players (Giannopoulos et al., 2017; Toselli & Campa, 2017). A bigger calf circumference in middle blockers and outside hitters is potentially the result of performing maximum intensity jumps, so anatomical adaptation to specific loads is thus possible (Cengizel & Cengizel, 2021). The upper arm circumference is defined by the cross-section of upper arm muscles, while muscle hypertrophy is partially an indicator of flexor strength and elbow extensors (Toselli & Campa, 2017). The extensors are of particular importance, dominantly musculus triceps brahii, whose activity is extremely important (Teoh et al., 2021) in preparation and main phases when performing overhead passes, spikes and serves.

The variables of Body height and Body weight are also highly correlated as, generally, taller athletes are heavier as well (Gualdi-Russo & Zaccagni, 2001). Without libero players, the average height is 195.75 cm and average weight is 90.91 kg. The variables of Body height and Body weight cause the values of the ectomorph somatotype index, which shows high results for volleyball players. It is somewhat higher among middle blockers (3.6), whose key role is in the block phase, as well as among setters (3.4), as opposed to outside hitters (3.1) and libero players (3.0).

Comparison with similar samples points to the fact that Croatian volleyball players match players from other countries in terms of their constitution (Petroski et al., 2013; Toselli & Campa, 2018). A low endomorph component was calculated, which is an indicator of the percentage of subcutaneous fat tissue in the body. The mesomorph component is most pronounced among players in the libero position, whereas the ectomorph component is highest among the tallest volleyball players – middle blockers. When comparing the characteristics of volleyball players from Brazil in the 2000's, the most common somatotype was mesomorph-ectomorph, which is also the case among Croatian players in this research as the somatotype of setters and middle blockers. The somatotype components match the ones that were measured on Italian volleyball players in the 90's (Gualdi-Russo & Zaccagni, 2001), however, differ from the results of a more recent research (Giannopoulos et al., 2017). It is to be expected that in the future the ectomorph component shall be increased, while the mesomorph somatotype component shall be reduced.

The limitation of this research is a relatively small sample, considering that the goal was related to calculating the somatotype of each playing role separately. The value of this sample is represented by the fact that they are top volleyball players, most of whom played for the national senior team in some part of their career. Longitudinal monitoring of the somatotypes of national team members is recommended in order to additionally confirm the correct criteria during the selection process by comparing them with the most successful volleyball nations.

Conclusion

The obtained results are similar to other results obtained on a sample of top-level senior male volleyball players, which indicates a quality-level player potential in the area of the tested characteristics. A statistically significant difference was found in morphological characteristics between the tested Croatian top-level volleyball players distributed according to their playing roles. The explanation lies in the specificity of volleyball and the requirements which must be met by players in a particular playing role. The efficiency in the performance of technical-tactical elements depends, among other things, on individual morphological measurements, as since the tasks for each playing role are also specific. As libero players do not take part in plays over the net, thus body height is not a key factor for achieving success for players in that position, however, due to the required speed of reaction and acrobatic landings after defending hard spikes, the mesomorph component is therefore an important one. Contrary to libero players, the height of reach in the block, as well as the ability to quickly set blocks present priorities for the position of middle blockers, and thus body height and the length of extremities is crucial. Outside hitters form in a way a link between liberos and middle blockers, as in addition to defensive techniques of service reception and defense, for which the mesomorph component is important, they also need longitudinal dimensionality of the skeleton which is relevant for playing on the net (spikes and blocks). The priority for setters is creating situations for the easiest possible attack by hitters. Although during three rota-

tions they participate in blocks and body height is important, their focus is on quality ball distribution towards the hitters. Constitution is a variable feature during growth and development, it is measurable and can be influenced by a planned and programmed training process. Numerous attempts to predict the development of morphological characteristics in younger age categories have been more or less successful, and it is thus important to continuously monitor competitors from the level of younger age categories to senior nation teams in order to gain an overall insight into the development of volleyball players from their entrance into competitive volleyball until playing for the national team. A certain number of sports also require selecting tall children. The trend of selecting taller and taller players is also present in other sports as well (basketball, tennis, handball, water polo), as a prerequisite for greater competitive and international success. In accordance with the mentioned trends, as well as with the trends in volleyball, the growth of the ectomorph component is to be expected. In keeping with the specificities of volleyball (no physical contact), which is evident in the results of longitudinal studies, the mesomorph somatotype component shall stagnate or only slightly grow.

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Conflict of interests:
The authors declare that there is no conflict of interests.

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