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Original scientific paper

Differences among Tennis Players Aged 12, 14 And 16 Years in Certain Morphological Characteristics: A Croatian Prospective

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ABSTRACT

A sample of young tennis players aged 12, 14 and 16 in Croatia. Sixty (60) tennis players ranked on the scale of the Croatian Tennis Association were analyzed through differences in morphological characteristics, as identified by a standard laboratory diagnostic procedure in Sports-diagnostic Centre of the Faculty of Kinesiology at the University of Zagreb. Significant differences were obtained in most of the monitored measures for the assessment of the morphological characteristics but the most significant differences were reflected in the variables for assessment of longitudinal dimensionality of the skeleton and body mass and voluminosity of the body. The statistical significance was defined at p<0.05. These differences may lead to decelerating the development of important fitness abilities (i.e., coordination), but also highlights the importance for changing the official propositions for the category of players between the ages due to the significant differences in certain morphological characteristics among all age categories. This study indicates an importance of understand grow characteristics of young players in order to effectively define tennis players playing style.

Key words: *morphology, tennis, young athletes, growth and development.*

Introduction

Over the last decade, technology advances in making of tennis equipment and preparing tennis players have caused certain changes in technique, strength and precision of executing tennis shots[1-3]. These advances have created an increased potential for relating to space and time. Numerous research studies demonstrated substantial acceleration of tennis game (greater force generated = tennis ball is flying faster, generating greater rotation = faster tennis ball's bounce). These advances have affected changes in the physical demands of high caliber competitive tennis[4-5]. For example, a great progress of serve performances can be highlighted due to significantly greater forces players nowadays generate while executing the serve[6]. More dominant start of the point enables the player to create greater space-time pressure on the opponent, and easier winning a point from the second or third shot[7]. Also, a good start of the point by serve may significantly influence the facilitated maintenance of the serve games and greater self-confidence throughout the game. Although this greater velocity of the serve may be ascribed to technological advances and tennis players' fitness preparation, the research also shows that the potential influence on the velocity is also an increase in the average height among players ranking within top 100 on the ATP scale[8]. It may therefore be identified that morphological dimensions of tennis players also have an impact on the development and dynamics of the game of tennis. Individual characteristics may play an important part in increase playing potential of players[9]. It is exactly this early specialization of the players that may contribute to more quality and more profound acquisition of specific successful at tournament competitions[11]. Few studies have simultaneously examined the quantitative differences among players aged 12, 14 and 16 in their growth characteristics. In the present study we investigated the size of difference in certain morphological characteristics among a sample of young tennis players aged 12, 14 and 16 in Croatia. Also, the presented results are a contribution to the development of reference values for specific age categories.

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Materials and Methods

Participants

The sample of the examined participants consisted of sixty tennis players (N=60), pertaining to three age categories: under 12 years of age (U12; N=20; 12.1±0.4 yrs), U14 (N=20; 14.0±0.6 yrs), and U16 (N=20; 15.9±0.4 yrs).

Instruments

Laboratory tests were conducted during morning hours in the Sports Diagnostic Centre of the Faculty of Kinesiology, University of Zagreb, Croatia. Morphological characteristics were measured in accordance with the instructions of the International Biological Programme[19]. The sample of the variables was composed of 13 anthropometric measures (3 measures of longitudinal dimensionality, 4 measures of transversal dimensionality, 4 measures of body voluminosity and mass, and 2 measures of the indicators of ballast mass and subcutaneous fat tissue):

Measures of the longitudinal dimensionality of the skeleton (1-3):

1. Body height (ALVT)
2. Leg length (ALDNL)
3. Arm length (ALDRL)

Measures of the transversal dimensions of the skeleton (4-7):

4. Diameter of the left knee (ATDIKL) (bicondilar breadth of the femur)
5. Diameter of the left elbow (ATDLL) (bicondilar breadth of the humerus)
6. Shoulders breadth (biacromial width) (ATSR)
7. Pelvis breadth (bicristal width) (ATSZ)

Measures of body voluminosity and mass (8-11):

8. Body mass (AVTT)
9. Thigh circumference (AVONDEL)
10. Forearm circumference (AVOPDL)
11. Lower leg circumference (AVOPOTL)

Ballast mass and measures of subcutaneous fat tissue (12-13):

12. Sum of 7 skinfolds (SUMA7KN)
13. Percentage of fat (AV%TOM)

Statistics

Basic descriptive statistical parameters of the variables were determined and variances (ANOVA) were statistically analyzed to determine significance of the differences among the three independent groups of tennis players with tabular and graphic overview of the results which have been obtained. By using descriptive statistics the basic statistical parameters were obtained for each variable; arithmetic mean (AM), standard deviation (SD), minimal (Min) and maximal (Max) value and measures of skewness and kurtosis. To determine differences between the different age groups of tennis players, the univariate analysis of variance was used (ANOVA). The aim of this procedure was testing of the hypotheses on the materiality of differences among arithmetic means of three groups of tennis players aged 12, 14 and 16 in each variable for the assessment of morphological characteristics. Eventually, the procedure for graphic presentation of differences obtained at the analyzed groups of tennis players will be used, by applying the Tukey's HSD post-hoc methods on the level of reaching a conclusion ($p<0.05$).

TABLE 1
VARIABELS FOR ASSESSMENT OF MORPHOLOGICAL CHARACTERISTICS

Name of anthropometric measures	ID of the Test	Brief explanation of the test
1. Longitudinal skeleton dimension	ALVT (cm)	Body height
2. Longitudinal skeleton dimension	ALDNL (cm)	Length of the left leg
3.Longitudinal skeleton dimension	ALDRL (cm)	Length of the left arm
4. Transversal skeleton dimension	ATDIKL (cm)	Diameter of the left knee
5. Transversal skeleton dimension	ATDLL (cm)	Diameter of the left elbow
6. Transversal skeleton dimension	ATSR (cm)	Shoulders' breadth
7.Transversal skeleton dimension	ATSZ (cm)	Pelvis breadth
8. Body volume and mass	AVTT (kg)	Body weight
9. Body volume and mass	AVONDEL (cm)	Volume of the left humerus extension
10.Body volume and mass	AVOPDL (cm)	Volume of the left forearm bones
11.Body volume and mass	AVOPOTL (cm)	Volume of tibia
12.Balast mass	SUMA7sf (mm)	Sum of 7 skin folds
13. Fat tissue under skin	AV%TOM %	% Fat Omron

Results

Table 1 indicates basic statistical parameters of the variables applied for the assessment of anthropometric characteristics. On the basis of the insight into presented statistical parameters rather sufficient distribution of the obtained results can be noticed. By comparison of standard deviations and minimum and maximum results sufficient sensitivity of tests may be identified, since in the interval of the minimum and maximum result there are more than three standard deviations, rather frequently even more than four. In general, all variables are sufficiently sensitive and to the sufficient extent they differentiate the examined participants who were included in testing for the assessment of morphological characteristics of the examined participants. Figures 1, 2 and 3 denote differences among certain age categories in variables for the assessment of longitudinal dimensionality of the skeleton. It was identified that there are significant differences among certain age categories in the indicators of longitudinal dimensionality of the skeleton, which could have been expected. By rule, these differences are the consequence of the growth and development, i.e. biological determinants. Body height (ALVT) is the variable at which constant progress can be registered. Therefore, tennis players aged under 12 are on average 157.79 cm tall, tennis players aged under 14 are 170.43 cm tall, while tennis players under 16 are 178.86 cm tall. Body height shows statistically significant difference among all three age categories; however, the biggest difference is spotted between tennis players aged 12 and 14. When it comes to the variable of the length of left leg (ALDNL) it may be determined that extremities grow from the age of 12 to the age of 16. However, it is interesting that this growth at tennis players aged 14 to 16 largely decelerates, i.e. almost stagnates. Therefore, the average value of leg length in U12 tennis players was 91.17 cm; at tennis players aged up to 14 years it reaches 98.49 cm; while at tennis players aged up to 16 years it reaches 101.73 cm. Therefore, there is a significant difference between tennis players aged 12 and 14 at the level of materiality ($p<0.05$), between 12 and 16 years of age ($p<0.05$). However, there is no statistically material difference between tennis players aged 14 and 16. The variable of the length of the left arm (ALDRL) acts similarly like body height. In other words, the increase of this variable for the assessment of the length of an extremity is constant. Statistically material difference was determined at the level ($p<0.05$) among all monitored categories of tennis players.

It is interesting to notice from graphs 4 and 5 that statistically material difference between the monitored competitive categories was not identified in the variables of the diameter of the left knee (ATDKL) and the elbow (ATTDLL). In the variable of the shoulders' breadth (ATSR) there is a statistically material difference among all age categories. It should be stressed that between 14 and 16 years of age a smooth deceleration occurred in the growth of the shoulders' breadth. However, the difference is still statistically material (Figure 6). Similar progress of results occurs in the variable of the breadth of the pelvis

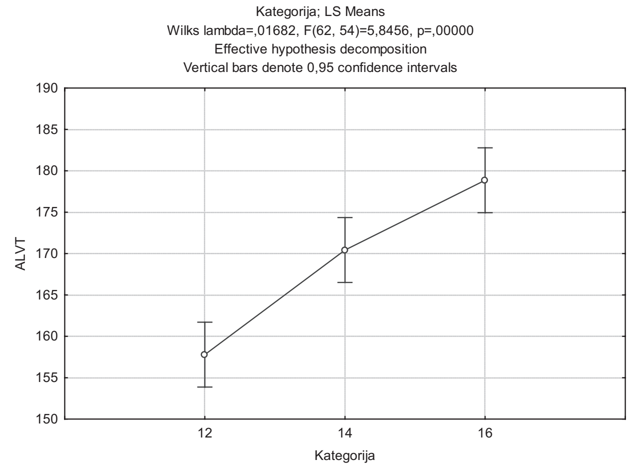

Fig. 1. Differences in values of ALVT among the monitored entity groups.

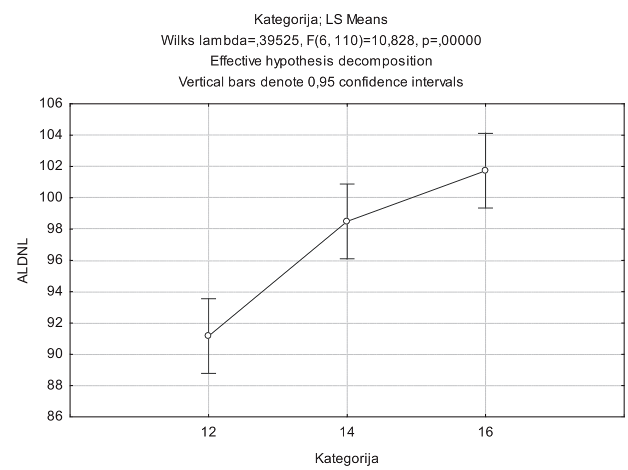

Fig. 2. Differences in values of ALDNL among the monitored entity groups.

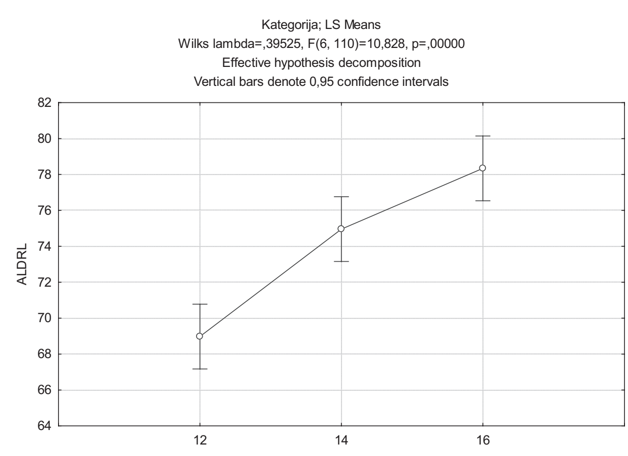

Fig. 3. Differences in values of ALDRL among the monitored entity groups.

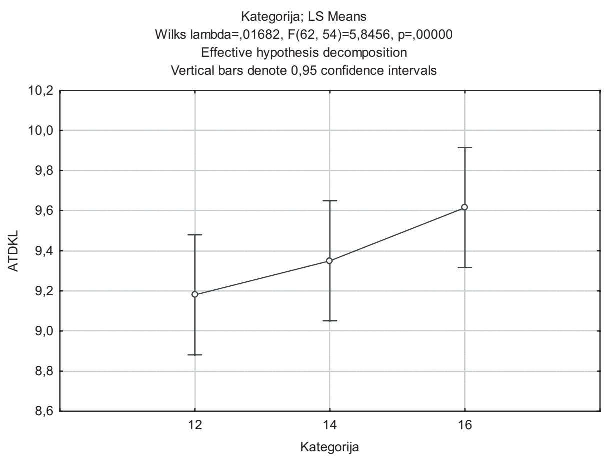

Fig. 4. Differences in values of ATDKL among the monitored entity groups.

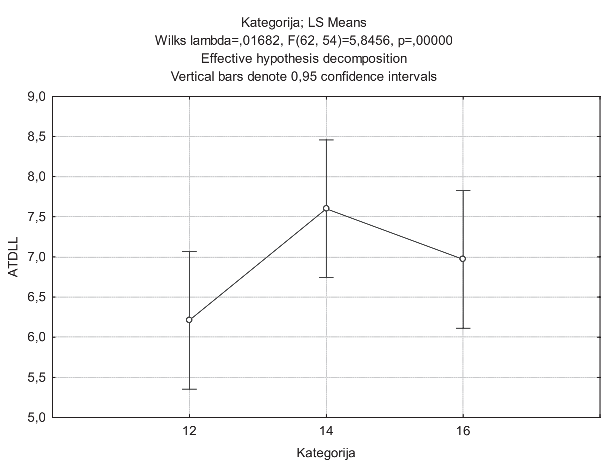

Fig. 5. Differences in values of ATDLL among the monitored entity groups.

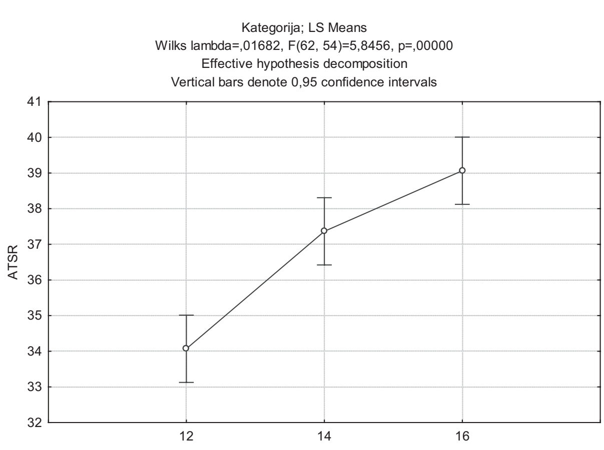

Fig. 6. Differences in values of ATSR among the monitored entity groups.

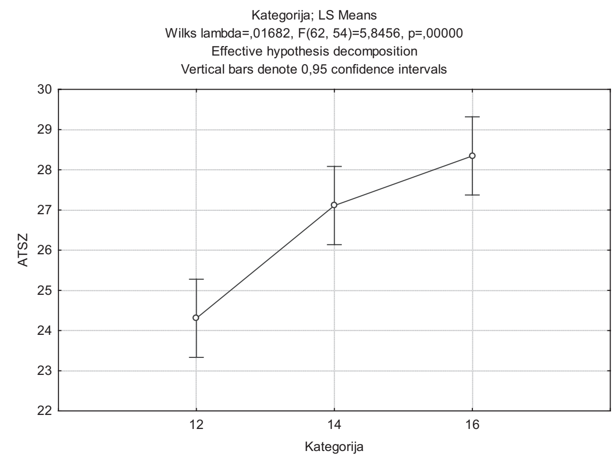

Fig. 7. Differences in values of ATSZ among the monitored entity groups.

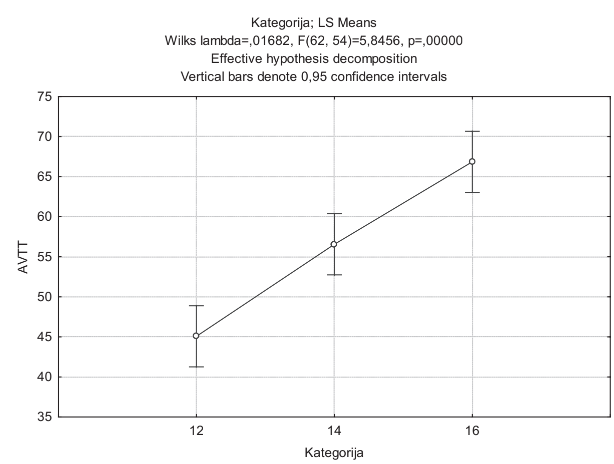

Fig. 8. Differences in values of AVTT among the monitored entity groups.

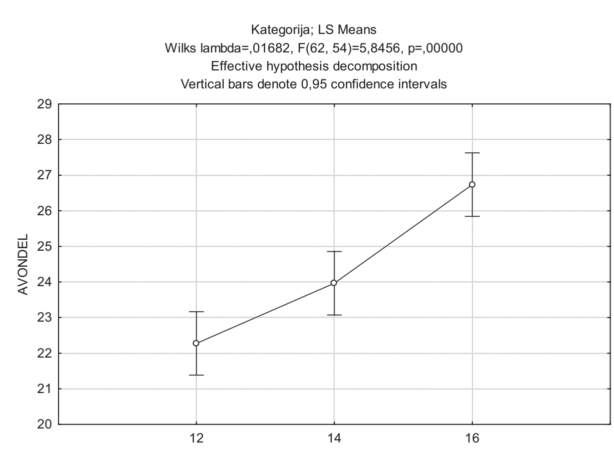

Fig. 9. Differences in values of AVONDEL among the monitored entity groups.

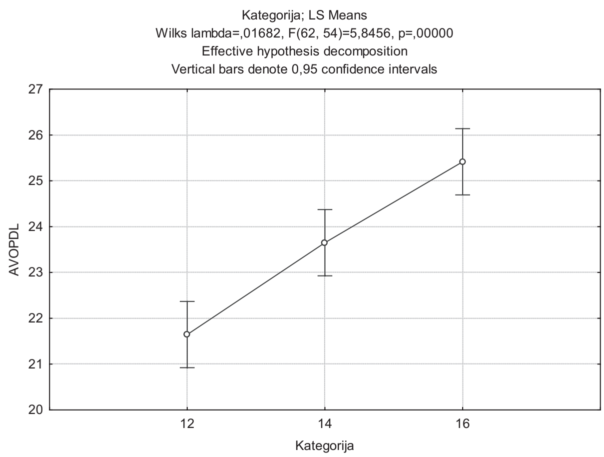

Fig. 10. Differences in values of AVOPDL among the monitored entity groups.

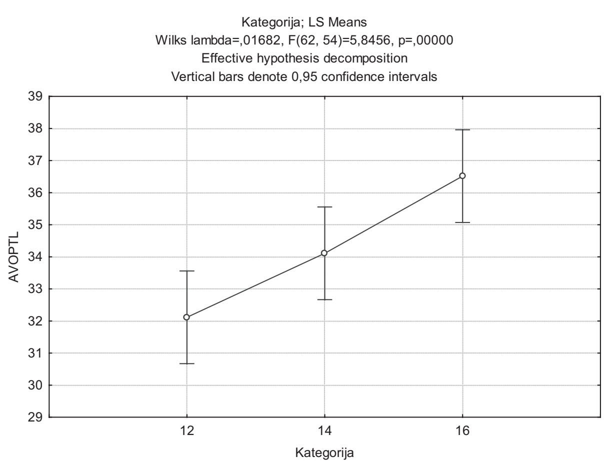

Fig. 11. Differences in values of AVOPTL among the monitored entity groups.

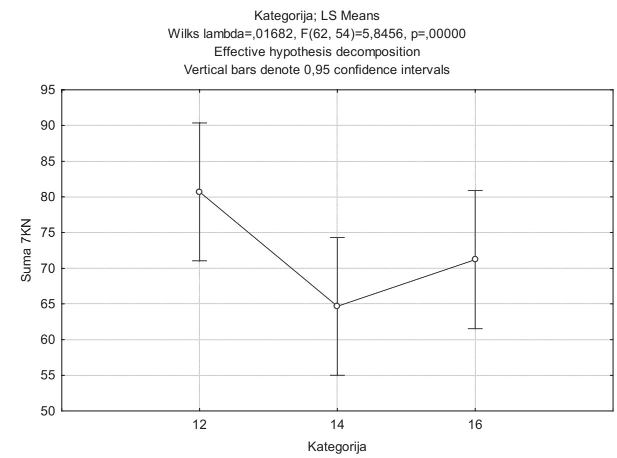

Fig. 12. Differences in values of SUMA7sf among the monitored entity groups.

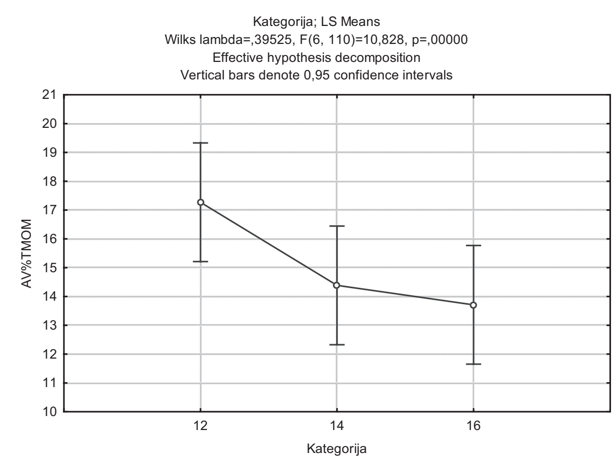

Fig. 13. Differences in values of AV%TMOM among the monitored entity groups.

(ATSZ), where material difference was spotted between age categories of 12 and 14 years, and 12 and 16 years at the error rate $p<0.05$. On the other hand, between the examined participants in the category 14 and 16 there is no material difference, i.e. they are attributed with approximately identical values (Figure 7). Figures 8-11 indicate differences among single age categories in variables for the assessment of body mass and volume, on the basis of four variables: body weight (AVTT), volume of the left upper arm in extension (AVONDEL), volume of the left forearm (AVOPDL) and volume of the left lower leg (AVOPTL). In all monitored variables for the assessment of body volume and mass, a statistically material difference is spotted except in the variable referring to the volume of the left forearm. At the variable referring to the body weight (AVTT) the linear progression of the value of results is spotted (arithmetic mean – AM: 12 years of age=45.07 kg; 14 years of age=56.56 kg; 16 years of age=66.85 kg), which is also expected because it is logical that with the increase in body height, muscle mass and subcutaneous fat tissue, the body weight also increases. Accordingly, among all three age categories there exists statistically material difference at the error rate $p<0.01$. The situation is similar at variables for the assessment of the body volume (AVONDEL / AVOPDL), where almost linear progression of the value of results is also spotted (arithmetic mean in the variable AVONDEL: 12 years of age=22.28 cm; 14 years of age=23.97 cm; 16 years of age=26.74 cm; arithmetic mean in the variable AVOPDL: 12 years of age=21.65 cm; 14 years of age=23.65 cm; 16 years of age=25.42 cm). It may be noticed that in the variable referring to the volume of the left lower leg (AVOPTL) there was no statistically significant difference among age categories. Figures 12 and 13 indicate differences among tennis players of different age categories in variables for the assessment of the indicators of the ballast mass and

TABLE 2
DESCRIPTIVE PARAMETERS OF THE MEASURED VARIABLES OF TENNIS PLAYERS

Variables	N	U12 $\overline{X}$± SD Min-max	U14 $\overline{X}$± SD Min-max	U16 $\overline{X}$± SD Min-max	p
ALVT	60	157.79±8.49 145.00–182.10	170.43±9.86 152.20–190.10	178.86±7.79 159.50–195.20	$, €, £
ALDNL	60	91.17±5.14 81.70–102.40	98.49±6.18 86.50–111.40	101.73±4.53 94.10–112.00	$, €
ALDRL	60	68.98±3.82 64.00–76.90	74.96±4.44 67.40–82.60	78.34±3.81 69.20–86.10	$, €, £
ATDKL	60	9.18±0.35 8.40–9.80	9.35±1.00 5.80–10.90	9.62±0.46 8.50–10.30	ns
ATDLL	60	6.21±0.39 5.30–7.00	7.60±3.27 6.30–21.40	6.97±0.46 5.40–7.50	ns
ATSR	60	34.07±2.22 29.90–38.80	37.37±2.47 33.20–41.30	39.07±1.51 36.20–42.00	$, €, £
ATSZ	60	24.31±1.96 20.80–29.00	27.11±2.13 22.20–32.30	28.35±2.40 24.20–33.00	$, €
AVTT	60	45.07±7.68 31.00–59.50	56.56±10.22 39.70–69.00	66.85±7.38 52.00–79.00	$, €, £
AVONDEL	60	22.28±2.12 18.20–26.70	23.97±1.93 20.30–27.00	26.74±1.91 23.20–30.40	$, €, £
AVOPDL	60	21.65±1.50 19.30–24.10	23.65±1.89 19.70–26.30	25.42±1.42 22.00–29.20	$, €, £
AVOPTL	60	32.12±3.71 27.10–44.60	34.11±2.39 28.10–37.70	36.52±3.43 33.00–48.90	€
Suma 7KN	60	80.70±29.23 41.23–170.17	64.67±14.90 39.67–95.83	71.20±17.93 51.77–132.10	ns
AV%TMOM	60	17.27±6.18 8.00–26.30	14.39±3.76 8.10–20.70	13.71±3.33 5.50–19.00	ns

Values are means ($\overline{X}$) ± standard deviation (SD) and min-max; U12 – tennis players under 12 yrs; U14 – tennis players 12–14yrs, U16 – tennis players 14–16¸yrs;
$^{\$}$ – significant U12: U14 p<0.05
$^{€}$ – significant U12: U16 p<0.05
$^{£}$ – significant U14: U16 p<0.05
^{ns} – not significant

subcutaneous fat tissue on the basis of two variables: sum of 7 skinfolds (SUM7sf) and % of fat (AV%TMOM). No material differences were noticed among competitive categories in any of the variables.

Discussion and Conclusion

The results of this study indicates that there are significant differences among certain age categories in the indicators of morphological characteristics. We can hypotheses these differences are the consequence of the growth and development, i.e. biological determinants. Body height shows statistically significant difference among all three age categories; however, the biggest difference is between tennis players aged 12 and 14. The probable cause for this is the consequence of the puberty period in which the examined participants are, as well as the trend of the spurt growth in height[12]. The fact that constant growth of body height appears at this age largely influences the creation of the training process which is particularly reflected to training of certain fitness abilities. Frequently these reasons lead to certain difficulties in performing movements acquired[13]. Special attention should be paid to working on some fitness abilities of tennis players, particularly on development of coordination and development of basic strength which would, in a certain way, compensate these problems of disproportion of morphological measures. Based on the results obtained it is feasible to infer that as of the age of 14 years onwards body height increases more on the account of the trunk growth than on leg length. This reflects the importance of core region conditioning. In other words, the leg length has already been stabilized in a certain way in the age period from 14 to 16 years. Statistical data related to the volumes of the upper and lower extremities (upper arm, forearm and lower leg) in this subject sample a tendency becomes obvious of bigger increments in body mass in the upper extremities. In general, the growth of the body volume and mass is principally influenced by the period of the puberty growth spurt, which is characterized by the changing of body proportions[14]. Body height and body mass among the examined participants aged 12, 14 and 16 indicate the fact that the examined participants of this research are placed right in the period of the most intensive growth and development. If the results obtained are compared with the results of the non-selected population of the same age[19], the examined participants of this research are to a certain extent taller (+6cm) and heavier (+5 kg). Tennis players have smaller quantity of fat tissue in relation to the non-selected population, it may be identified that a focused tennis and conditioning training may positively affect the development of the musculature and the reduction of the subcutaneous fat tissue. Due to sudden increase in body height and body weight in puberty phase, there occurs a slowdown in the development of important conditioning competences of tennis players, particularly coordination. For this reason, actions should be taken for a prompt establishment of the impaired conditioning competences in respect of the accelerated growth in height, since it leads to specific and irrational movements. The performance of motor movements is also supported by a distinguished disproportion in the increase of the bones' length, as well as the body volume and mass due to which actions should be taken for bringing this disproportion into alignment. There are lot of game situations in tennis when the longitudinal dimensions (i.e., arm length) are exceptionally important, especially when running at short balls, and also side balls. The so far researches show that morphological variables are a significant factor of successfulness in tennis[16,17]. For example, body height may present an advantage in tennis, and it is considered to be one of rather significant morphological characteristics[10], particularly in the games played on fast surfaces. The researches indicate that the body height over 180 cm largely contributes to the stronger execution of the first shot, i.e. the serve exceeding 200 km/h[9]. This confirms one of more relevant factors of the acceleration of the first shot is the continuous growth of the body height in the last ten years at the players ranking among top 100 on the ATP scale[7,8]. More expressed longitudinal dimensionality of tennis players enables the execution of the serve in a higher striking point (contact point of the racquet and the ball) which positively influences not only greater velocity but also the precision and the better angle of playing the serve[10]. It also enables easier execution of forehand, backhand, volley and smash at the higher striking point and better reach of more distant balls, which is particularly stressed while covering the space during the net game[10]. This contributes to the more aggressive game style, which is usually accompanied by approaching the net. On the contrary, players with less expressed body height move faster; they have a better developed agility (due to a lower placed center of gravity). Also, since they approach the net less frequently, they often have a greater range of the shots from the baseline. Morphological characteristics are also important to understand in order to effectively define tennis players playing style. It is essential to understand the player's style that is being trained, as many differences do exist and the training programs will differ depending on the style. For example, traditional serve and volley player has to have long extremities in order to hit the serve in a higher striking point and to catch a wide balls as well. The goal of the counterpuncher is to chase down every ball and make sure the opponent has to hit many balls each rally to win any points. This game style is based on great side-to-side and up and back movement with consistent strokes and margin for error. Form morphological prospective these players are usually shorter. However, these type of players are rarely seen in today's game. These morphological facts are very important to understand in order to effectively define how to train young tennis players and how to distribute a training load. Diameters of the elbow, diameters of the knee, shoulders' and pelvis breadth and volumes of tennis players are exceeding the average of the non-selected population[19]. Under the influence of the sudden growth in height over a short period of time, body proportions are significantly altered. Upper and lower limbs become longer, the breadth of shoulders and the pelvis widens, while the volumes increase. If we take into account the smaller percentage of the body fat at tennis players, it may be identified that this indicates their bigger muscle mass. The emphasis should also be put on the results of a number of scientific researches which indicated the disproportion between the dominant and non-dominant sides of the body, which refer to specificity of tennis as sport[16,17]. A dominant hand of the tennis players may be even up to 20% in its volume bigger than a non-dominant[18]. The above mentioned shows that a long-term exposure to training stimuli largely influences the increase of the volume and the diameter of upper extremities of the dominant body side[18], but also the importance of performing compensational workouts in order to accomplish muscle balance of the trunk and extremities of the left and the right body side. In this way, significant influence can be made on the prevention of injuries, greater continuity of partaking in competitions and prolongation of the sports career[18]. Due to all of the specifics of the morphological development of the examined participants who are predominantly under the influence of the period of the puberty growth spurt, actions should be undertaken for the prompt establishment of the impaired coordination competences through a specific conditioning training. It should be particularly focused on the development of coordination but also of the primary strength through workouts of repetitive and explosive strength which would serve the function of a regular development. The findings from this study also highlight the importance for changing the official propositions for the category of players between the ages of 12, 14 and 16 due to the significant differences in certain morphological characteristics among all age categories. It could be expected that due to the reduced span of chronological age fewer varieties are possible in the morphological characteristics of tennis players (i.e., 12-13).

The paper gives an analysis of differences in morphological indicators of the tennis players' aged 12, 14 and 16. Significant differences were obtained in most of the monitored measures for the assessment of the morphological characteristics. It may be assumed that training incentives of the conditioning, but also technical-tactical type, as well as tennis competitions, positively affected development of some morphological characteristics of boys and young tennis players included in this research. However, the factors of the motor development and psycho-social maturing, which intensify changes under the influence of the system of training, competition and measures of recovery which occur at tennis players of this age, must not be neglected. It is well-known that intensive growth and development at this age both lead to an increase of the body height and mass, and the gain in height and weight in respect of boys during the puberty is still significant. All of these indicate the relevance of the proper training load and nutrition s directed towards the development of the needed morphological characteristics as an important part of the readiness of the selected tennis players. Morphological characteristics are also important to understand in order to effectively define tennis players playing style. Also, these characteristics measured in early years could be used in talent selection purposes (i.e., body height). The presented results are a contribution to the development of reference values for specific age categories and standardization of diagnostic procedures in tennis; there is a need for creation of a data base for the purpose of better selection, planning and control of the training process of young tennis players.

Key points

The results indicate significant differences in morphological characteristics of tennis players aged 12, 14 and 16, which may lead to decelerating the development of important fitness abilities (i.e., coordination).

The results of the research indicate the importance of the quality based approach in the conditioning of young tennis players.

Morphological characteristics are important to understand in order to effectively define tennis players playing style.

The presented results are a contribution to the development of reference values for specific age categories.

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RAZLIKE MEĐU TENISAČIMA U DOBI OD 12, 14 I 16 GODINA U NEKIM MORFOLOŠKIM KARAKTERISTIKAMA: HRVATSKI POTENCIJAL

S A Ž E T A K

Primarni cilj ovog istraživanja bio je istražiti kvantitativne promjene u morfološkom prostoru kod mladih tenisača u dobi od 12 do 16 godina. Šestdeset (60) tenisača rangiranih na ljestvici Hrvatskog teniskog saveza bilo je uključeno u ovo istraživanje. Ispitanicima su mjereni u Sportsko-dijagnostičkom centru Kineziološkog fakulteta Sveučilišta u Zagrebu gdje su provedena mjerenja za utvrđivanje njihova morfološkog statusa. Rezultati ukazuju kako se ispitanici različitih natjecateljskih skupina značajno razlikuju u varijablama za procjenu morfološkog prostora. Te su razlike najuočljivije u varijablama za procjenu longitudinalne dimenzionalnosti skeleta (ALVT, ALDRL i ALDNL), te u varijablama za procjenu mase i volumena tijela (AVTT, AVONDEL i AVOPDL). Manje razlike uočene su kod varijabli za procjenu transverzalne dimenzionalnosti skeleta (ATSR i ATSZ). Razlike su utvrđene pri razini statističke značajnosti $p<0.05$. Rezultati ovog istraživanja nedvojbeno ukazuju kako period puberalnog zamaha intenzivnog rasta i razvoja, u kojem se ispitanici ove studije u trenutku mjerenja nalaze, značajno utječe na promjene tjelesnih dimenzija. Ovo ukazuje na važnosti kvalitetno strukturiranog i metodički oblikovanog trenažnog plana i programa teniskog, ali i kondicijskog treninga mladih tenisača. Naime, jedino takav pristup može rezultirani kvalitativnim promjenama stanja treniniranosti mladih tenisača koji se nalaze u burnoj fazi intenzivnog rasta i razvoja.