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Trend indicators of changes in body composition in soccer players in different periods of their career

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Abstract

In order to monitor proper growth and development in a particular sport, body composition monitoring has a great significant, which gives clear indicators about the state of trainings and nutritional status of young athletes. It is very important to analyze physical system in soccer players, not only to evaluate variations of dimensions in quantitative and qualitative meaning, but also in a direction of soccer players selection in the certain competitive categories and for a certain team position. Therefore this research had the primarily aim to analyze the trend of body composition in different periods of soccer players' career. The total sample of respondents (n = 271) is consisted of seven sub-samples of different age categories of soccer players competing in Bosnia and Herzegovina, U10 (n = 28), U12 (n = 54), U13 (n = 48), U14 (n = 62), U16 (n = 27), U18 (n = 24) and seniors (n = 28). The subject of this study included the body composition of soccer players in order to analyze the trend of dimension changes during soccer career. The changes in dimensionality are analyzed by one - way analysis variance (One way ANOVA) which is the simplest model from a large family techniques dealing with analysis of variance. Analysis results showed that soccer players during their career have had a very dynamic pace of growth and development, with specific periods in which it is accelerated or slowed down. In the period since beginning of dealing with soccer to the period of senior stuff, occurs the continued growth appears with the indicators that define the height, mass, basal metabolism, amount of the fluid in the body and the amount of fat free mass in the body composition. The variable that define the body mass index (BMI), body resistance (IMPEDANCE), percentage (FAT %) and mass portion of fat tissue in body structure (FATMASS) changes of dimensionality have a different pace and sign of movement. It can be concluded that soccer players during their career have rapid growth in height, whose largest increase is between the age period of 13 and 14 (10,21 cm), they linearly gain in mass whose largest increase is between the age period of 13 and 14 (8,7 kg) and between the age period of 16 and 17 (9,1 kg). We have a continuous increase in dimensions of indicators of basal metabolism, fat tree body mass and amount of fluid in the body. Changes in body resistance, amount and percentage of fat in the overall body mass have different signs depending on the age and growth competing category and have fall of values till the age period of 18.

Key words: **soccer players, body composition, changes in dimensionality**

Sažetak

U cilju praćenja pravilnog rasta i razvoja u određenom sportu veliki značaj ima i praćenje tjelesne kompozicije koja daje jasne pokazatelje o stanju treniranosti i uhranjenosti mladih sportaša. Analizirati tjelesni sastav kod nogometaša je veoma bitno, ne samo s ciljem ocjene varijacije dimenzija u kvantitativnom i kvalitativnom smislu, već i u pravcu selekcije igrača u određenim takmičarskim kategorijama i za određene pozicije u timu. Stoga je ovo istraživanje imalo prvenstven cilj da se kod nogometaša analizira trend promjena tjelesne kompozicije u različitim razdobljima nogometne karijere. Ukupan uzorak ispitanika (n =271) sačinjen je od sedam subuzoraka različitih uzrasnih takmičarskih kategorija nogometaša u Bosni i Hercegovini, U10 (n=28), U12 (n=54), U13 (n= 48), U14 (n=62), U16 (n=27), U18 (n=24) i seniori (n=28). Predmetom ovog istraživanja obuhvaćena je tjelesna kompozicija kod nogometaša u cilju analize trenda promjena dimenzija u toku nogometne karijere. Promjene u dimenzionalnosti analizirane su jednosmjernom analizom varijance (One way ANOVA), koja predstavlja najjednostavniji model iz brojne porodice tehnika analize varijance. Analizom dobivenih rezultata utvrđeno je da nogometaši u toku svoje karijere imaju veoma dinamičan tempo rasta i razvoja, sa određenim periodima u koji je on ubrzan ili usporen. U razdoblju od početka bavljenja nogometom pa do seniorskog kadra dolazi do kontinuiranog porasta u pokazateljima koji definišu visinu, masu, bazalni metabolizam, količinu tečnosti u tijelu i količinu bezmasne mase u sastavu tijela. Kod varijabli koje definišu tjelesni indeks (BMI), otpor u tijelu (IMPEDANCE), procentualni (FAT %) i maseni udio masnog tkiva (FATMASS) u strukturi tijela, promjene dimenzionalnosti imaja različit tempo i predznak kretanja. Može se zaključiti da nogometaši u toku svoje karijere imaju ubrzan rast u visinu čiji je prirast najveći između trinaeste i četrnaeste godine (10,21 cm), linearno dobijaju na masi čiji najveći prirast je između trinaeste i četrnaeste godine (8,7 kg) i šesnaeste i osamnaeste godine (9,1 cm). Kontinuiran porast dimenzija imamo kod pokazatelja bazalnog metabolizma, bezmasne mase tijela i količine tečnosti u tijelu. Promjene u otporu tijela, količini i procentu masti u ukupnoj masi tijela su različitih predznaka zavisno od uzrasta i uzrasne takmičarske kategorije i imaju pad vrijednosti do osamnaeste godine.

Ključne riječi: **nogometaši, kompozicija tijela, promjene u dimenzionalnosti**

Introduction

The proper guidance and monitoring of children's growth and development is the primary important significance of each sport activity. The growth is quantitative increase of dimensions in human body, while the development is qualitative increase of organs and organ systems of a certain individual. Growth status refers to the size attained in a given chronological period, usually as height and weight, while development (maturation) refers to the progress towards the biologically mature status (Malina 2003). For the purpose of proper growth and development monitoring in a particular sport, also monitoring of physical system, that gives clear indicators about the state of training and nutritional status of an athlete, has a great significant. It is also very important to analyze physical system of soccer players, not only with the aim to evaluate variation of dimension for quantitative and qualitative purpose, but also for the purpose of player's selection in the particular competing categories and for the particular team position. These data provide clear guidelines for the coach to continue monitoring, planning and programming training process. The special interests of researchers are reserves of fat tissue, because ballast mass weight adversely affects the ability of the organism. The body composition of an athlete significantly changes from year to year, and this problem has been topic for many research samples and sources of variables

and it has expanded the practical applicability in sport. The majority of the traditional methods are based on two components model of the body, according to which the total body mass consists of fat mass and fat free mass. According to this fact the fat mass consists of so called essential and unessential fat. The essential fat constitutes 2 % of fat free body mass in the shape of lipid body components and is necessary for healthy functioning of organism. The unessential fat constitute: subcutaneously fatty tissue (adipose tissue), yellow marrow transplant and abdominal visceral fat. For determining the physical structure different indirect methods were used previously as Ramadan and Byrd (1987), Green (1992), Dowson and associates (1999), where by measuring body dimensions and by the usage of adequate regression equations in a simply way, the indirect evaluation of fat content , bone-and-muscle tissue in the overall structure of athletes was obtained. Development of modern software systems, beside anthropometric, have brought many methods for estimation and establishing the body composition, the most famous and those that provide the most accurate results are : Hydrostatic Weighing, method of an air plethysmography (Bod-Pod), (Ostojic 2007; Kutac and associates 2008; Misigoj –Durakovic 2008).

Bioelectrical Impedance Analysis (BIA) as fast, noninvasive and relatively cheap method with acceptable precision, has gained the trust of both medical and sport experts in recent years. That is the method that evaluates the structure of body composition by broadcasting low, colorless dose of electric power of 800μA and the frequency of 50 KHz through human body (organism). Electric power passes through the body – without resistance through the fat free tissue (muscles, bones, internal organs), while the resistance occurs when it passes through fatty tissue (Kutac and associates 2008). This resistance is called bioelectrical impedance and it is measured by the monitors of body fat. Entering respondents' data (height, weight, age, status), based on installed software the physical structure of the respondents' bodies can be calculated. Although anatomical- physiological characteristics for all people, in particular are equal, although among them, there are significant differences that should be taken into consideration for work with children. For each coach who works in training process, is vary important to know developmental characteristic of children working with. Differences, with other factors, mostly stem from belonging to different periods of growth and development. Periods of growth have their own lawfulness and characteristics by which they differ, and their pace (tempo) cannot be skipped. The child's growth and development include many elements, from those on cells basis to those that are an integral part of single person's life, such as his social, cultural and sport activity. From conception to maturity, the processes of growth and development pass into extreme harmony, which is unique for each person, and this harmony is dependent not only to inherited characteristics (traits), but it is also dependent to effect of external factors (proper nutrition, climate, physical activity, … etc). For the age period of 12 to15 years the major transformation occurs in the child's development and that is puberty. During that period, huge changes occur in child's organism, which leave significant traces later in life. This period corresponds to juvenile period of acceleration, where is the growth in height more prominent than the increase in width.

The basic parameters of physical (body) development are height and width, as well as their structural components: muscular mass and fatty tissue. Analyzing these components the pace and lawfulness of body construction can be determined. Mean body weight show significant differences in the inter-year population growth in general as well as individual. The body weight is also the basic parameter of the level and pace development of the body structure, but it belongs to the so – called dynamic variable dimension, because it is liable to environmental influences and it can show large variations, even during the day.

The determination of fat and fat free components and the body composition of an athlete, with the knowledge of the optimal values for a certain sport, also take an important place in a contemporary training process. The relation between fat and fat free components of an athlete greatly varies (changes) depending on gender, the level of trainings, periodization and the age. Significantly higher portion of fat have female persons, and the highest ratio of fat free part to fat part is achieved about the age of 20, and the ratio is later decreased in non athletes. After the age of 20, a normal increase of 1% in body fat is expected for each decade. The upper limits of fat percentage is 25% for men and 30% for women, while the minimal values range from 5% to 10% for men and 5% to 17% for women (Wilmore, 1986; Wilmore and Costill, 2004).

According to World Health Organization (WHO) BMI lower than 18.5 is considered as insufficient weight and it could show the existence of malnutrition, improper nutrition or other health problem, while BMI higher than 25 is considered as excess of weight, and when BMI is over 30 it is considered as obesity. Total Body Water is the percentage of water in the body of an athlete and it tells us about the proper and optimal fluid intake for athletes. The normal TBW percentage varies among women from 45% to 60%, for men: 55% to 65%. For athletes, the image is approximately 5% higher than these ranges, as they have more muscular mass and bones, and muscles contain more water than fat tissue (Misigoj-Durakovic 2008). Basal Metabolic Rate (BMR) is daily minimal level of energy or calories, necessary for effective body functioning while resting. A person with a high BMR can spend (consume) a lot more calories while resting than the person with lower BMR, and this is based on the level of muscular mass. The full understanding of body metabolism enables the user to see, according to significant obtained values, how many calories he should take in accordance with his body size and lifestyle. And when an athlete has more muscles or generally more activities, he has to take more calories necessary for work, so that nutrition and characteristic of the training program can be based on this information.

Methods

The Sample of Respondents

The research has been conducted on a sample of 271 soccer players, classified into seven sub-samples (U10, U12, U13, U14, U16, U18 and seniors), who represents different age competing categories of soccer players in Bosnia and Herzegovina. The main criterion for selection of respondents was to have had, at least 2 years in training process (U10), and that they have had good health status without any psychophysical aberrations.

The Sample of Variables

The body composition of players' groups was determined by the method of Bioelectrical Impedance Analysis (BIA). For that purpose the electrical balance TANITA TBF-300 (Tanita corporation of America Inc.) was used, which, on the basis of the initial date (age and height) shows **the following variables:**

1. Body height (HEIGHT)
2. Body mass (MASS)
3. Body Mass Index (BMI)
4. Basal Metabolic Rate (BMR)
5. Electric Body Resistance (IMPEDANCE)
6. The percentage of Fat in the Body (FAT%)

7. The portion of Fat in Body Mass (FAT MASS)
8. The portion of Fat Free Mass in Body (FFM)
9. Total Body Water (TBW)

in body composition of optimal values with reference to researched age of an athlete. The measures of heights were taken by standard portable anthropometry.

Data Processing Method

For each sub-sample, for all variables, central and dispersions parameters of the variables were calculated (arithmetic mean, standard deviations, minimal and maximal results), the changes in dimensionality were defined by one-way analysis of variance (One way ANOVA), that represents the simplest model from a large family techniques dealing with analysis of variance. The trend of growth, individually for each variable is graphically shown.

Results and Discussion

The results of research are shown in Tables 1-3, and the trend of growth is shown by graphs individually for each variable. The change of body height shows that the arithmetic mean of variables (AVIS) statistically significantly changes throughout the period from the age of 10 to seniors, and the slope of growth curve shows that there is a slightly intensive increase from the age of 13 to 14 years (10,2 cm) and from the age of 16 to seniors (8,5 cm). The body mass of soccer players (AMAS) up to period of puberty has slowed growth and since this period it has followed the growth of curve variable height and has continuous upward trend of growth in the period when the seniors end their growth. The variable which represents the proportion of body mass, expressed in kilograms, and square of body height value expressed in meters, up to the age of 12 years has a slight decrease of value and then there is a continuous trend of growth as well as in those 2 variables. Basal Metabolic Rate (BMR) which represents the daily minimal level of energy or calories necessary for effective organism functioning while resting, portion of Fat Free Mass in the total body mass (FFM) and Total Body Water (TBW) which represents the entire amount of water in the body, have also a continued trend of growth in this period and it moves in the continuous line with a larger increment up to senior period. Converting the amount of fluid in the total body mass, into the percentage share, we will see that the amount of fluid expressed as a percentage of body mass ranges from 59,8 % (10 years), 63,84 % (12 years), 62,31 % (13 years), 64,67% (14 years), 67,05 % (16 years), and then it comes into the period of stabilization and a slight decrease of the value in seniors. The variable that measures the amount of fat tissue in total body mass (FATMASS), a sudden increase during the age period of 12 years to the age period of 13years is evident, and during this period there was a flexion of the growth curve, and reduced but continuous decrease of the amount of fat tissue by the age of 14. And the percentage of fat tissue (FAT%) in the total subjects' mass has a similar growth curve, just what is notable here is the continued increase in the age period of 12 to 13 years (2%), and then the sudden decrease (fall) of percentage fat portion in the age period of 14 years (3,5%). The only variable in the body composition which has a continuous decrease in the value is impedance, which represents the resistance in the body of respondents. It is evident that in this period appears a significant decrease (decline) of fat tissue, and increase in muscular mass, water and other fat free components that leads towards a decrease of body resistance and to a better flow of electricity, on whose principle this research technique is based.

Table 2.- Test of homogeneity of variance in body composition variables

	Levene Statistic	df1	df2	Sig.
AVIS	,712	6	264	,640
AMAS	1,562	6	264	,158
BMI	1,288	6	264	,263
BMR	1,462	6	264	,191
IMPEND	2,733	6	264	,014
FAT%	6,100	6	264	,000
FATMASS	3,212	6	264	,005
FFM	1,827	6	264	,094
TBW	2,149	6	264	,048

Table 3.- One way analysis of variance (One way ANOVA)

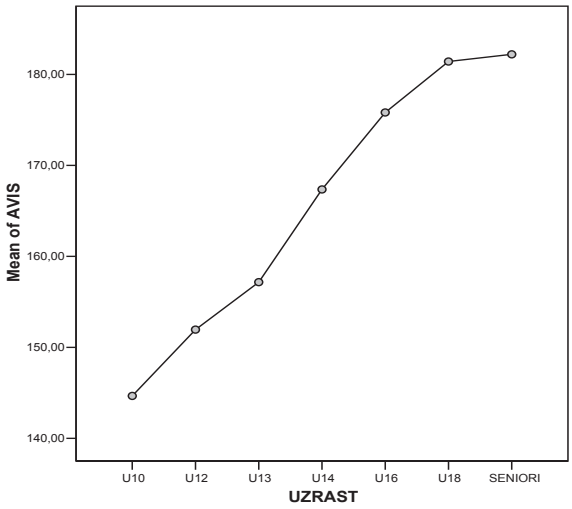
Variable		Sum of Squares	df	Mean Square	F	Sig.
AVIS	Between Groups	41566,547	6	6927,758	155,201	,000
	Within Groups	11784,246	264	44,637		
	Total	53350,794	270			
AMAS	Between Groups	45707,451	6	7617,909	127,218	,000
	Within Groups	15808,537	264	59,881		
	Total	61515,988	270			
BMI	Between Groups	960,239	6	160,040	30,986	,000
	Within Groups	1363,514	264	5,165		
	Total	2323,754	270			
BMR	Between Groups	176077472,883	6	29346245,480	96,647	,000
	Within Groups	80162127,228	264	303644,421		
	Total	256239600,111	270			
IMPEND	Between Groups	622674,209	6	103779,035	35,442	,000
	Within Groups	773029,260	264	2928,141		
	Total	1395703,469	270			
FAT%	Between Groups	2741,625	6	456,937	22,884	,000
	Within Groups	5271,489	264	19,968		
	Total	8013,114	270			
FATMASS	Between Groups	278,635	6	46,439	5,052	,000
	Within Groups	2426,701	264	9,192		
	Total	2705,336	270			
FFM	Between Groups	45986,379	6	7664,397	223,028	,000
	Within Groups	9072,389	264	34,365		
	Total	55058,768	270			
TBW	Between Groups	25097,006	6	4182,834	219,522	,000
	Within Groups	5030,329	264	19,054		
	Total	30127,335	270			

Table 1.- Descriptive parametres of body composition variables by age

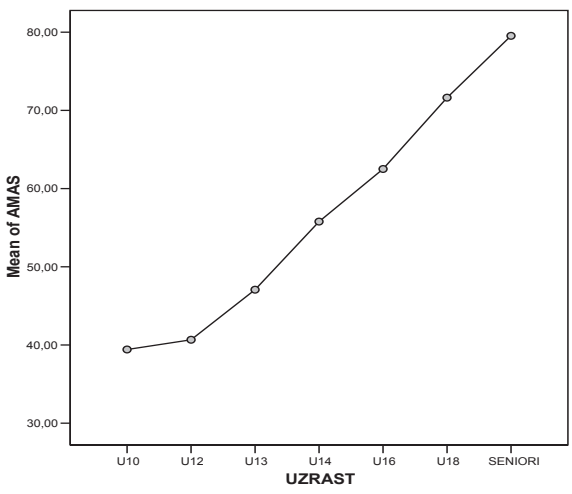
Variable	age	N	Mean	Std. Dev.	Std. Error	Min	Max
AVIS	U10	28	144,6643	6,37618	1,20499	135,00	165,00
	U12	54	151,9500	6,94096	,94454	140,20	171,60
	U13	48	157,1646	6,40623	,92466	142,50	167,20
	U14	62	167,3581	7,21357	,91612	151,20	181,00
	U16	27	175,8148	7,24986	1,39524	161,00	191,00
	U18	24	181,4167	4,97749	1,01602	174,00	189,00
	SENIORI	28	182,2071	6,36460	1,20280	172,40	197,00
	Total	271	163,7594	14,05687	,85389	135,00	197,00
AMAS	U10	28	39,4214	7,12052	1,34565	29,40	58,30
	U12	54	40,6685	6,37551	,86760	31,20	57,00
	U13	48	47,0729	7,37935	1,06512	34,20	67,40
	U14	62	55,7790	9,75761	1,23922	38,20	86,40
	U16	27	62,5037	8,55833	1,64705	45,70	80,90
	U18	24	71,6250	5,83090	1,19023	58,90	82,50
	SENIORI	28	79,5321	6,75415	1,27641	66,10	94,30
	Total	271	54,0635	15,09427	,91691	29,40	94,30
BMI	U10	28	18,7214	2,39403	,45243	14,40	23,10
	U12	54	17,5444	2,04687	,27854	12,70	24,70
	U13	48	18,9938	2,47862	,35776	14,10	24,50
	U14	62	19,7565	2,61356	,33192	15,30	28,90
	U16	27	20,1519	1,93398	,37219	16,30	25,00
	U18	24	22,1333	2,30928	,47138	18,20	29,80
	SENIORI	28	23,9750	1,50791	,28497	20,80	26,80
	Total	271	19,7594	2,93368	,17821	12,70	29,80
BMR	U10	28	5680,0714	512,74323	96,89936	4983,00	7045,00
	U12	54	5804,2222	464,13843	63,16124	5113,00	7018,00
	U13	48	6270,1250	523,99564	75,63226	5333,00	7707,00
	U14	62	6912,9677	688,81940	87,48015	5669,00	9077,00
	U16	27	7428,9259	614,76049	118,31071	6221,00	8708,00
	U18	24	7842,5000	421,32782	86,00318	7116,00	8675,00
	SENIORI	28	7985,5000	467,04084	88,26242	7198,00	9208,00
	Total	271	6695,3321	974,18456	59,17750	4983,00	9208,00
IMPEND.	U10	28	566,4643	62,80156	11,86838	465,00	678,00
	U12	54	567,5556	61,68443	8,39419	447,00	702,00
	U13	48	544,1667	50,38969	7,27312	441,00	664,00
	U14	62	485,4355	59,51763	7,55875	316,00	599,00
	U16	27	449,5556	43,50007	8,37159	395,00	559,00
	U18	24	447,7083	42,37358	8,64947	380,00	531,00
	SENIORI	28	460,1429	37,98607	7,17869	382,00	555,00
	Total	271	511,0443	71,89765	4,36747	316,00	702,00
FAT%	U10	28	17,5786	5,41557	1,02345	10,00	33,00
	U12	54	12,4111	4,80097	,65333	1,40	25,30
	U13	48	14,3479	5,68016	,81986	6,60	28,30
	U14	62	10,8290	4,54722	,57750	4,60	25,60
	U16	27	8,0556	3,12463	,60134	2,70	16,00
	U18	24	5,7625	2,13110	,43501	2,10	9,20
	SENIORI	28	9,2929	2,12549	,40168	5,00	13,20
	Total	271	11,5812	5,44777	,33093	1,40	33,00

FATMASS	U10	28	7,2071	3,34420	,63199	3,00	17,70
	U12	54	5,2241	2,65422	,36119	,50	14,40
	U13	48	7,0063	3,63098	,52409	2,40	17,70
	U14	62	6,3597	3,63595	,46177	2,00	18,20
	U16	27	5,2037	2,51679	,48436	1,50	12,90
	U18	24	4,1792	1,66027	,33890	1,40	7,20
	SENIORI	28	7,4286	1,89734	,35856	3,70	11,80
	Total	271	6,1376	3,16540	,19228	,50	18,20
FFM	U10	28	32,2571	4,59214	,86783	26,20	45,60
	U12	54	35,4611	4,75995	,64775	28,70	48,00
	U13	48	40,0667	5,07993	,73322	30,80	51,30
	U14	62	49,4677	7,29956	,92704	36,10	73,00
	U16	27	57,3000	6,83453	1,31531	42,20	68,10
	U18	24	67,1500	5,32198	1,08634	57,50	76,60
	SENIORI	28	72,1036	6,00342	1,13454	59,90	85,30
	Total	271	47,9185	14,28010	,86745	26,20	85,30
TBW	U10	28	23,6179	3,36750	,63640	19,20	33,40
	U12	54	25,9611	3,47994	,47356	21,00	35,10
	U13	48	29,3354	3,71670	,53646	22,60	37,60
	U14	62	36,0758	5,65641	,71836	20,00	53,40
	U16	27	41,9444	5,00802	,96379	30,90	49,90
	U18	24	49,8208	3,65180	,74542	42,60	56,60
	SENIORI	28	52,8036	4,39937	,83140	43,90	62,40
	Total	271	35,1096	10,56327	,64167	19,20	62,40

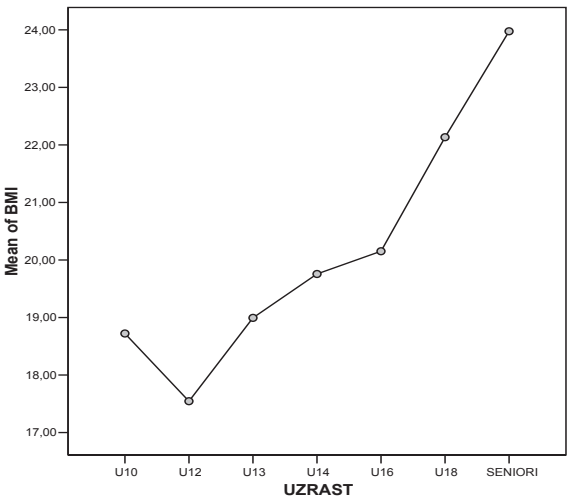
Graph 1.- Trend of growth of variable HEIGHT



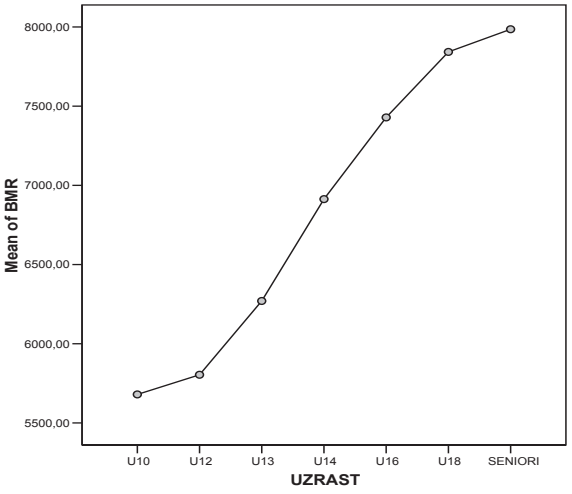
Graph 2.-Trend of growth of variable MASS



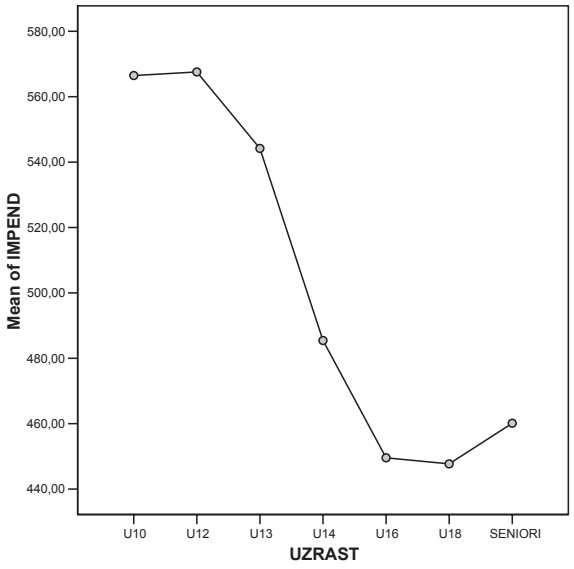
Graph 3.- Trend of growth of variable BMI



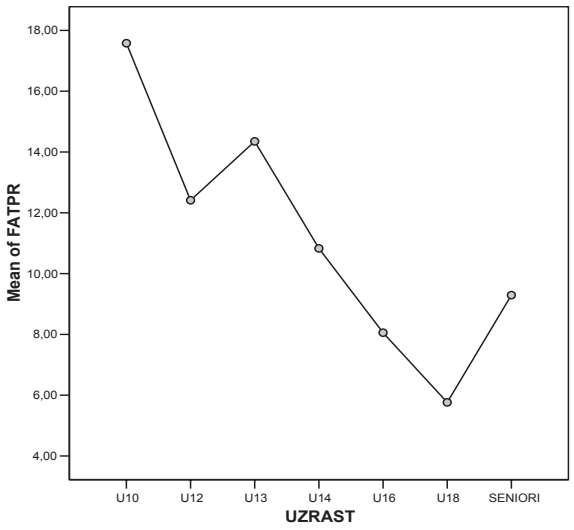
Graph 4.- Trend of growth of variable BMR



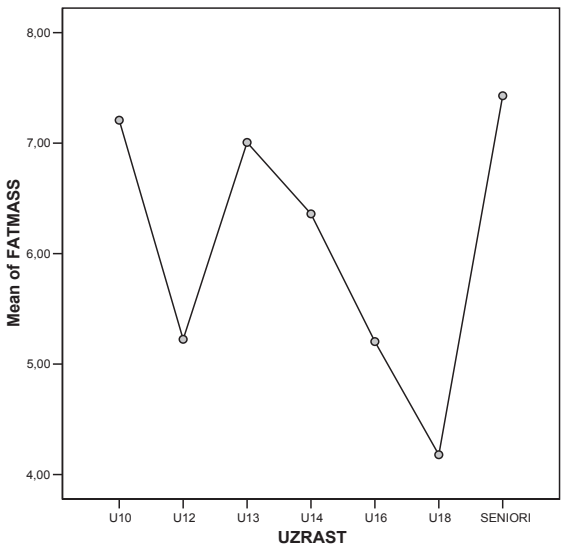
Graph 5.- Trend of growth of variable IMPENDANCE



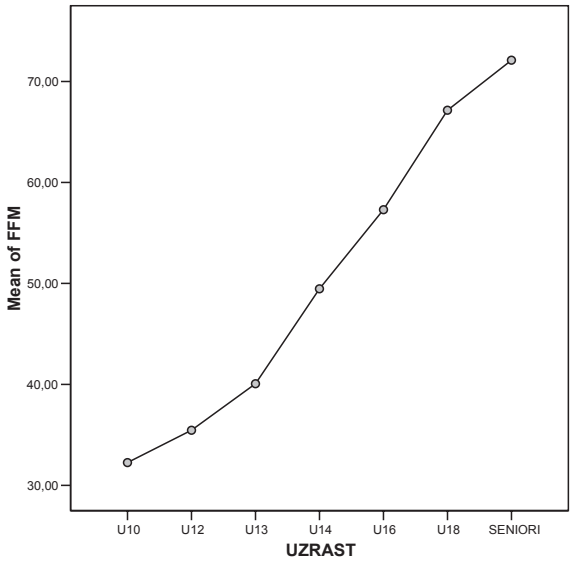
Graph 6.- Trend of the growth of variable FAT%



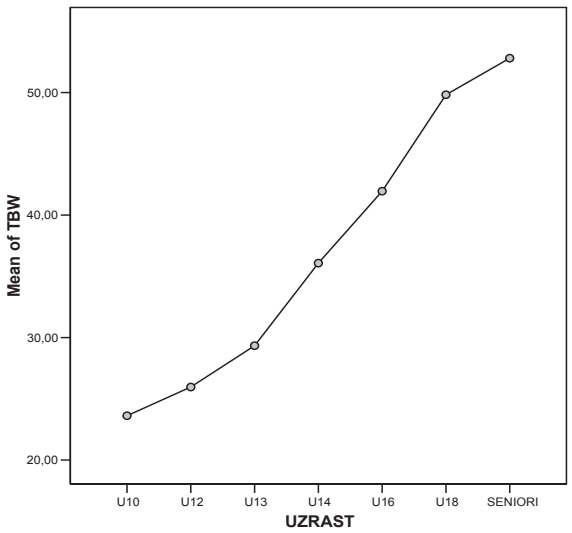
Graph 7.- Trend of growth of variable FATMASS



Graph 8.- Trend of the growth of variable FFM



Graph 9.- Trend of growth of variable TBW



Conclusion

The aim of this research was that through a cross – section view, determines the trend of changes among the indicators of body composition in soccer players in different age periods. On the studied sample of 271 subjects (respondents), distributed into 7 sub-samples, 7 variables were measured by Bioelectrical Impedance Analysis (BIA).For this purpose the electrical balance TANITA TBF-300 (Tanita corporation of America Inc.) was used. All obtained values were analyzed individually, and by basic descriptive data (central and dispersion parameters) it can be concluded that the distribution of results is within the normal distribution. On the basis of results determined by the analysis of variance (One way ANOVA) it can be concluded that there is a significant trend of changes in body composition in all variables on the level ($p<.01$). Analysis of inter-annual increases based on arithmetic means of variables, can be concluded that soccer players rapidly grow and develop, to grow and gain in weight (mass) slightly more in comparison to previous year. We can see the evident, changeable trend of changes in the percentage and

mass of fat (adipose) tissue where comes to decrease of the values during the age period of 10 to 12 years, when there is a growth of fat (adipose) tissue till the age of 13, and then comes to a sudden decrease of the value about the age of 16, which can be explained by the rapid growth and development, as well as the impact of training activities of the respondents followed by increased amount of muscular mass and decreased fat portion in body composition. The amount of fluid in body (Total Body Water) also has a continuous growth curve, but if we express it in percentages then we will notice that the amount of fluid in the body of players increases gradually (U10=69,56%; U12=63,8%; U13=62,3%; U14=64,67%; U16=67,05%; U18=69,56%) till the senior period when it starts to decrease slightly (SENIORI=66,39%). By the obtained results, a general conclusion can be drawn, and this conclusion is that soccer players in the period of the beginning of training process till the senior period have a rapid growth and development, followed by increase of muscular mass and decrease of the amount and the percentage fat portion in the body composition. To this dynamic trend of changes in body composition, beside the factors of growth and development, certainly a great influence has systematically planned and programmed training technology in soccer clubs.

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