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Morphological Characteristics and Bilateral Differences of Youth U13, U15, U17 and U19 Male Football Players

Características Morfológicas y Diferencias Bilaterales de los Jóvenes Futbolistas Masculinos U13, U15, U17 y U19

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SUMMARY: An anthropometric and body composition analysis was conducted on 123 competitive young male football players of different age groups (U13; U15; U17 & U19) with at least 4 years of training load. 3D anthropometric measurement were performed by the NX-16 ([TC]2 , 3D body scanner Cary, North Carolina). Body composition was measured by the bioelectrical impedance with InBody 720 (Biospace Ltd.). Anthropometric and body composition characteristics among different age groups and asymmetries between the left and right side of the upper and lower limbs were analysed for treated age groups. The results showed differences in anthropometric and body composition variables among all age groups in all observed variables (Height, Weight, Basal Metabolic Rate, Skeletal Muscle Mass, Body Fat Mass, Percent Body Fat, Abdominal Obesity Degree, Body Mass Index, Body Fat Mass, Skeletal Lean Mass and Fat Free Mass). The results also showed that young football players of age group U13 differed statistically in four (from 7) paired variables (Arm Lean Mass, Leg Lean Mass, Forearm Girth and Calf Girth), U15 in three variables (Upper Arm Girth, Thigh Girth and Calf Girth), U17 in five variables (Arm Lean Mass, Leg Lean Mass, Upper Arm Girth, Forearm Girth and Calf Girth) and U19 in four observed variables (Arm Lean Mass, Leg Lean Mass, Upper Arm Girth and Calf Girth). All of the age groups differed statistically in calf girth paired variables. Puberty time probably had an impact on the results, and in future research more focus should be placed on puberty characteristics variables.

KEY WORDS: Anthropometry; Body composition; Youth football; Body symmetry.

INTRODUCTION

Success in football (sport) depends on many factors, which are correlated: external factors, internal factors and training process (Pocrnjic, 1999). Success in sport is also directly correlated with body characteristics, as are body dimensions, body composition and somatotype (Carter & Heath, 1990). Football players should have, along the required technical - tactical skills motor and functional abilities an adequate combination of body characteristics to be successful (Pocrnjic, 1999).

Anthropometric and body composition indicators are important factors affecting the specific attributes of today's football players (Mala *et al*., 2018). The variability in anthropometric indicators and body composition parameters during this period can be used to identify an elite player at an adolescent age (Milsom *et al*., 2015). It has been reported that football players with increased body size dimensions have improved speed, power, and strength performance, especially during the pubertal years (Carling *et al*., 2009).

Various research has shown, that in sports morphological and functional asymmetries exist (Hart *et al*., 2014; Filipcic *et al*., 2016; Rauter *et al*., 2017) and therefore they have to be studied, so that their impact on health condition and sport performance can be determined. Body asymmetries can refer to differences between the left and right side of the body (thorax, pelvis and trunk), between the left and right limbs, between the upper and lower part of the body which can be seen from limbs dimensions, body fat percentage, bone density, lean body mass, muscle mass etc. (Krzykala, 2012).

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Football is a complex sport, requiring the repetition of many disparate actions (Rampinini *et al*., 2007) and consists of various technical elements (Pocrnjic, 1999), some of which are performed with a ball and some without one; some are performed with the player's feet while others are performed with other parts of the player's body. Many of those are unilateral as kicking, passing, dribbling, jumping and changing directions. It was determined that performing repeated and prolonged unrepeated movements with asymmetrical movement patterns can result in differences between the two body sides or between agonist and antagonist muscles (Masuda *et al*., 2005). In football, players usually have a preferred lower limb over the other. This preference can lead to bilateral asymmetries and improve the risk of injury in players (Domingues & Castro, 2020).

Various methods are available, to acquire and analyse morphological characteristics in sports practitioners but they vary depending on the time available for measurement, funds and the accuracy of the results (Krzykala, 2012). From modern 3D anthropometry and bio electrical impedance we can compare both sides of the body and determine the status of body symmetries (Simenko & Vodicar, 2015). After literature review, we concluded, that there are some studies regarding morphological asymmetries with the use of 3D body scanning method in combination with electrical bio impedance in judo (Simenko & Vodicar, 2015), cycling (Rauter *et al*., 2017) and dancing (Prus & Zaletel, 2022), but not in football.

Therefore, the aim of this study is to research the status of morphological asymmetries in young football players age groups under 13, 15, 17 and 19. The aim is also to analyse the differences in anthropometric and body composition characteristics among the included age groups, which also has not been well researched. More specifically, we aimed to research body asymmetries, when they occur and the development of them through maturation. We wish to examine whether football load under the Slovene training programme develops a young body in a symmetrical or asymmetrical dimension.

MATERIAL AND METHOD

The study was conducted in accordance with the ethical standards outlined in the 1964 Declaration of Helsinki, following the 6th revision of 2008. The study was approved by the Committee for ethical questions in sport, Faculty of Sport, University of Ljubljana. Written informed consent was obtained from all participants or their parents or guardians after they were adequately informed about the study.

Subjects. This study included 123 participants (football players) of different age groups (U13 (n=37), U15 (n=32), U17 (n=35) & U19 (n=19)). All participants were recruited from the same well-organised football school. All age groups had a minimum of five activities (training sessions and matches) a week. Age group U19 competed in the second division, all other age groups competed in the first division. The minimum period of football training experience was four years (average of 7, 38 years). Their mean age was 17.2± 2.45 years, their body height 167.2±12.6 cm, and their body weight was 56.9±7.3 kg.

Anthropometric measurements. Body height (BH) was measured with an anthropometer GPM (Switzerland).

Measurements of body composition were performed using bioelectrical impedance analysis (BIA), with the InBody 720 Tetrapolar 8- Point Tactile Electrode System (Biospace Co., Ltd.). The InBody 720 apparatus, which was validated by Wang *et al*. (2014), utilizes the technology for measuring body composition by using the method of Direct Segmental Multi-Frequency Bioelectrical Impedance Analysis. With InBody 720 we measured Body Weight (BW), Basal Metabolic Rate (BMR), Skeletal Muscle Mass (SMM), Body Fat Mass (BFM), Percent Body Fat (PBF), Abdominal Obesity Degree (AOD), Body Mass Index (BMI), right and left Arm Lean Mass, right and left Leg Lean Mass, Body Fat Mass (BFM), Skeletal Lean Mass (SLM) and Fat Free Mass (FFM).

3D body scan measurements: anthropometric body measurement was performed by the 3D body scanner NX-16 ([TC]2, Cary, North Carolina), which was validated in a previous study (Simenko & Cuk, 2016) and represents a non-invasive scanning method to produce a true-to-scale 3D body model in 8 seconds. The scanner uses photogrammetry technology, which projects patterns of structured white light on to the body. 32 cameras then record the way in which the pattern is distorted by the shape of the body. From this, the body shape is digitally reconstructed from a raw photonic point cloud data, which leads to a surface reconstruction of the body and allows for automatic landmark recognition as well as electronic tape measurements. With the software, we extracted the measurements of five paired measurements: left and right Long Shoulder Height, left and right Upper Arm Girth, left and right Forearm Girth, left and right Thigh Girth and left and right Calf Girth.

Experimental procedure. The subjects were measured by the same examiner, one with extensive experience in the physiological laboratory at the Faculty of Sport, University of Ljubljana, in controlled environment conditions. Before measurements, a full calibration of the NX-16 scanner was made. The full calibration was done using: 1) the reference cylinder which was 150 cm in height and had diameter of 28 cm, and 2) an additional set of reference balls which included two strings of calibration balls and a single calibration ball (diameter of all balls was 15 cm). The scanner calibrated itself in a way that it measured a circumference on every 10 mm from top to bottom of the cylinder, and calculated circumferences standard deviation that should not have exceeded the prescribed limits of 0.9 mm (Simenko & Cuk, 2016). Calibration with a string of balls was successful and within the acceptable range of the circumferences standard deviation of 0.417 mm. Further, subjects were instructed to remove all jewellery and clothes. They entered the scanner barefooted and in formfitting bright colour underwear. They stood in a standardized position, with their feet located on landmarks on the scanner's floor (feet set straight, not inwards or outwards), grabbing the handles inside of the scanner with a natural standing posture (shoulders not elevated, elbows stretched, upright position of the back, chin slightly lifted). Subjects with long hair were instructed to tie their hair in a bun (Sˇimenko & Cˇuk, 2016). A 3D Body Measurement System Version 7.4.1 software was used to create the initial point cloud that was then processed into a 3D body model, from which customized measurements could be extracted. A multi-scan option with three consecutive scans was used to obtain the data. Multiscan options merged all three files of three consecutive scans and gave one merged file with the means of all three consecutive scans. Scanning of the three consecutive scans lasted 24 s and subjects were instructed to be as still as possible (Simenko & Cuk, 2016). Statistical Analysis. Analyses were conducted using SPSS for Windows (Version 21.0; SPSS, Inc., Chicago, USA). Data were presented according to descriptive statistics (Means ± SD). Furthermore, we performed the following tests: Kolmogorov-Smirnov test, standard error of measurement (SEM), ANOVA differences among age groups and a paired sample T-test for differences between the left and right side within an age group. All statistical significance for the ANOVA and t-test was set to p<0.05.

RESULTS

Table I shows descriptive statistic of anthropometric and body composition characteristics of Youth Male Football Players (Body Height, Body Weight, BMR (Basalic Metabolic Rate), SMM (Skeletal Muscle Mass), BFM (Body Fat Mass), PBF (Percent Body Fat), AOD (Abdominal Obesity Degree), BMI (Body Mass Index), FFM (Fat Free Mass) and SLM (Skeletal Lean Mass). The results show statistically significant differences among different age groups in all ten observed variables.

Table II. Present results and statistically significant differences between the left and right sides of different body segments among young football players of age group under 13. The statistical differences were found in four paired variables: arm lean mass t(36)=2.99, p= 0.005; leg lean mass t(36)=2.18, p= 0.036; forearm girth t(36)=5.64, p= 0.000 and calf girth t(36)=4.55, p= 0.000.

Table III. Present results and statistically significant differences between the left and right sides of different body segments among young football players of age group under 15. The statistical differences were found in three paired variables: upper arm girth t(31)=2.58, p= 0.015; thigh girth t(31)=-2.50, p= 0.018 and calf girth t(31)=2.60, p= 0.014.

Table IV. Present results and statistically significant differences between the left and right sides of different body segments among young football players of age group under 17. The statistical differences were found in five paired variables: arm lean mass t(34)=2.82, p= 0.008; leg lean mass t(34)=4.98, p= 0.000; upper arm girth t(34)=4.03, p= 0.000; forearm girth t(34)=2.77, p= 0.009 and calf girth t(34)=3.38, p= 0.002. Close to the limit of statistical significance in U17 age group is thigh girth variable p= 0.051.

Table V. Present results and statistical significant

Table I. Anthropometry and body composition.

Variables	Age group												
	U13		U15		U17		U19		95% CI				
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Lower	Upper	df	F	p
Height (cm)	153.49	8.87	165.91	8.26	176.09	6.11	179.95	4.51	164.98	169.49	122	77.51	.000
Weight (kg)	43.88	8.88	52.93	9.38	64.96	8.51	74.01	10.75	54.35	59.43	122	57.34	.000
BMR (cal)	1156.52	134.50	1380.91	157.13	1630.11	138.96	1737.07	149.86	1392.21	1486.46	122	96.49	.000
SMM (kg)	19.66	3.68	25.77	4.32	32.98	3.88	35.90	4.18	26.23	28.87	122	99.89	.000
BFM (kg)	7.47	4.48	6.14	3.59	6.63	3.46	10.72	5.76	6.59	8.18	122	5.24	.002
PBF (%)	16.18	7.37	11.19	4.83	9.90	3.95	14.03	5.11	11.68	13.85	122	8.92	.000
AOD	000.78	0.03	0.77	0.03	0.78	0.04	0.81	0.05	0.77	0.79	122	5.18	.002
BMI	18.49	2.66	19.12	2.45	20.89	1.92	22.82	2.91	19.50	20.52	122	15.85	.000
FFM (kg)	36.41	6.22	46.80	7.27	58.33	6.43	63.29	6.93	47.32	51.68	122	96.70	.000
SLM (kg)	34.33	5.86	44.16	6.86	55.02	6.02	59.66	6.52	44.63	48.74	122	97.14	.000

differences between the left and right sides of different body segments among young football players of age group under 19. The statistical differences were found in four paired variables: arm lean mass t(18)=3.17, p= 0.005; leg lean mass t(18)=3.95, p= 0.001; upper arm girth t(18)=3.20, p= 0.005 and calf girth t(18)=4.39, p= 0.000.

Table II. Differences among age group U13 selected paired variables.

Variable	Age Group U13						
	Right		Left				
	Mean	SD	Mean	SD	df	t	p
Arm Lean Mass	1.61	0.41	1.59	0.41	36	2.99	.005
Leg Lean Mass	5.43	1.21	5.40	1.19	36	2.18	.036
Long shoulder Height	122.88	8.10	123.29	7.94	36	-1.64	.110
Upper Arm Girth	24.84	3.22	24.48	3.25	36	1.66	.105
Forearm Girth	22.41	1.77	21.70	1.89	36	5.64	.000
Thigh Girth	49.89	6.54	49.83	6.68	36	0.29	.777
Calf Girth	32.73	2.79	32.31	2.66	36	4.55	.000

Table III. Differences among age group U15 selected paired variables.

Variable	Age Group U15						
	Right		Left				
	Mean	SD	Mean	SD	df	t	p
Arm Lean Mass	2.28	0.50	2.27	0.50	31	0.78	.439
Leg Lean Mass	7.40	1.42	7.39	1.42	31	0.82	.421
Long shoulder Height	133.33	7.40	133.85	7.17	31	-1.82	.078
Upper Arm Girth	26.29	3.20	25.68	2.69	31	2.58	.015
Forearm Girth	23.49	1.59	23.45	1.79	31	0.34	.734
Thigh Girth	53.87	6.97	54.46	6.91	31	-2.50	.018
Calf Girth	35.08	2.69	34.85	2.64	31	2.60	.014

Table IV. Differences among age group U17 selected paired variables.

Variable	Age Group U17						
	Right		Left				
	Mean	SD	Mean	SD	df	t	p
Arm Lean Mass	3.11	0.45	3.08	0.43	34	2.82	.008
Leg Lean Mass	9.35	1.10	9.26	1.06	34	4.98	.000
Long shoulder Height	142.06	5.94	142.03	6.10	34	0.11	.910
Upper Arm Girth	29.88	2.65	29.02	2.47	34	4.03	.000
Forearm Girth	25.36	1.39	25.06	1.57	34	2.77	.009
Thigh Girth	57.43	4.65	57.02	4.73	34	2.03	.051
Calf Girth	36.55	1.93	36.27	2.00	34	3.38	.002

Table V. Differences among age group U19 selected paired variables.

Variable	Age Group U19						
	Right		Left				
	Mean	SD	Mean	SD	df	t	p
Arm Lean Mass	3.42	0.49	3.37	0.48	18	3.17	.005
Leg Lean Mass	10.18	1.14	10.11	1.14	18	3.95	.001
Long shoulder Height	145.27	4.79	145.36	4.37	18	-0.30	.768
Upper Arm Girth	31.74	3.21	31.06	3.29	18	3.20	.005
Forearm Girth	26.57	1.86	26.41	2.00	18	1.07	.298
Thigh Girth	63.68	6.62	63.39	7.69	18	0.65	.524
Calf Girth	37.93	2.62	37.46	2.64	18	4.39	.000

DISCUSSION

In Table I. there are statistically significant differences among the observed age groups in anthropometric and body composition indicators and the results are similar but not the same as in findings of Mala *et al*. (2020) in their research. Physical growth is a continuous process that occurs during the years of infancy, childhood, and puberty, and ceases when adult stature is reached (Mala *et al*., 2020). In BH Mala *et al*. (2020) found significant differences among U12 till U15 age groups and not in groups from U16 till U19, which differs from our findings. The differences in BH between U13, U15, U17 age groups are more than 10 cm and between U17 and U19 they are only slightly over 3 cm which is similar to findings of Mala *et al*. (2020) who reported an increase of BH around 7 cm a year from U13 till U15 age group. Stratton *et al*. (2004) reported the rate of body mass gain reaches a maximum of 20–25 kg between the 12th and 16th year (increase in fat free mass, decrease in fat mass) and from the 16th to the 20th year, it increases by 10 kg on average, which is consistent with our results. Other studies revealed an association between age and body composition across adolescence. Both increase (Le Gall *et al*., 2002) and decrease (Manna *et al*., 2010) and fluctuation (Nikolaidis & Karydis, 2011) of body fat across adolescence were reported in relevant studies. In our study BFM, PBF and AOD results are decreasing from U13 to U17 age groups. Later an increase in BFM, PBF and AOD values were shown in U19 age category. One reason can be that U19 competed in the second division (U13, U15 and U17 competed in the first Division) which can be explained with findings of Deprez et. al. (2015) that higher-class players were significantly smaller and slimmer than lower-level and average skill-level players. The greatest differences in BFM, PBF and AOD values in our research were found from U13 to U15 age groups, which is consistent with findings of Male *et al*. (2020). BMI constantly increases from U13 to U19, which is consistent with the results reported by Nikolaidis & Karydis (2011) in their research. FFM strongly contributes to strength and power performance (Milanese *et al*., 2015) and is considered a major precondition for good performance in various sports and for the optimal individual performance of soccer players. Our research highlights that SMM, FFM and SLM rapidly increase from U13 to U17, which is similar to findings in researches from Stratton *et al*. (2004), and Mala et. al. (2020) who found that the rapid changes in FFM, especially in males occur from 13 to 14 years of age.

Morphological asymmetry, defined as the difference between the right and left part of the body, is most likely a consequence of specific, mostly asymmetrical movements, without adequate compensation (Mala *et al*., 2020). Tables II., III., IV. and V. present anthropometric and body composition values of selected variables of the left and right, the lower and upper body limbs of different age groups and their statistically significance. The statistically important differences were: between the left and right calf girth in all observed age groups, between the left and right arm and leg lean mass in U13, U17 and U19 age groups, between the left and right upper arm girt in U15, U17 and U19 age groups, between the left and right forearm girth in U13 an U17 and between the left and right thigh girth only in U15 age category. No statistically significant differences between the left and right long shoulder height were in any of the observed age groups. From our study, we can confirm that asymmetries are present in all the observed age groups, the most in U17 age group. Male *et al*. (2020) who compared the differences in muscle mass of low limbs found statistically important differences only in U17 age group and not in U12 to U16 age groups. The results of our study indicate that body asymmetries already exist by 12-year-old male football players, which is in accordance with indication of Malinowski (2004) that normal human body asymmetry appears very soon and the manifestation of morphological asymmetry intensifies with aging, which is connected with functional asymmetry.

The limitations of the study are: we made a comparison of different football players of different age groups and from the same football club; only chronological age, without pubertal stage detection, was used to define the groups. For future research it might be better to include more football players from different football clubs and to use a longitudinal study with the same football players, following their progress from their early beginnings with serious football training (U8 age group) till adultness (U21 age group).

CONCLUSION

The present study demonstrated that the growth development and the body composition characteristics of young male football players included in our study change with and are proportional to age. Statistically significant differences are present from age group to age group, therefore, it is appropriate for each age group to compete separately so that nobody has advantage because of the biological development. The eldest U19 age group competed in the second division, consequently lower number of football players with less good body characteristics were involved, which can be connected with a lower level of motor abilities and possibly also with a lower level of technical skills.

As it is evident from our study morphological body asymmetries in football players exist in all age groups. Number of asymmetries fluctuate from age group to age group. Body asymmetries are present in lower as well as in upper body limbs in all treated age groups. The most evident asymmetries are the ones in calf girth in all treated age groups. This can be important information for all youth football coaches and should be taken into account when planning age appropriate training sessions. Asymmetries are still present in age group U19 and most likely also in adult football players with probability for asymmetries to increase. Therefore, regular observation of body characteristics is required for better planning of the training process.

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RESUMEN: Se realizó un análisis antropométrico y de composición corporal en 123 jugadores de fútbol masculino jóvenes competidores de diferentes grupos de edad (U13, U15, U17 y U19) con al menos 4 años de carga de entrenamiento. La medición antropométrica 3D se realizó con el NX-16 ([TC]2, escáner corporal 3D Cary, Carolina del Norte). La composición corporal se midió mediante la impedancia bioeléctrica con InBody 720 (Biospace Ltd.). Se analizaron las características antropométricas y de composición corporal entre los diferentes grupos de edad y las asimetrías entre los lados izquierdo y derecho de los miembros superiores e inferiores para los grupos de edad tratados. Los resultados mostraron diferencias en las variables antropométricas y de composición corporal entre todos los grupos de edad en todas las variables observadas (Talla, Peso, Tasa Metabólica Basal, Masa Muscular Esquelética, Masa Grasa Corporal, Porcentaje de Grasa Corporal, Grado de Obesidad Abdominal, Índice de Masa Corporal, Masa Grasa Corporal, Masa magra esquelética y Masa libre de grasa). Los resultados también mostraron que los jugadores de fútbol jóvenes del grupo de edad U13 diferían estadísticamente en cuatro (de 7) variables pareadas (masa magra del brazo, masa magra de la pierna, circunferencia del antebrazo y circunferencia de la pantorrilla), U15 en tres variables (circunferencia del brazo superior, circunferencia del muslo y circunferencia del muslo). Circunferencia de la pantorrilla), U17 en cinco variables (Masa magra del brazo, Masa magra de la pierna, Circunferencia del brazo superior, Circunferencia del antebrazo y Circunferencia de la pantorrilla) y U19 en cuatro variables observadas (Masa magra del brazo, Masa magra de la pierna, Circunferencia del brazo superior y Circunferencia de la pierna). Todos los grupos de edad difirieron estadísticamente en las variables pareadas de circunferencia de la pierna. El tiempo de la pubertad probablemente tuvo un impacto en los resultados, y en investigaciones futuras se debe prestar más atención a las variables de las características de la pubertad.

PALABRAS CLAVE: Antropometría; Composición corporal; Fútbol juvenil; Simetría corporal.

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