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CHARACTERISTICS OF BODY TISSUE COMPOSITION AND FUNCTIONAL TRAITS IN JUNIOR FOOTBALL PLAYERS

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ABSTRACT
Purpose. The aim of this study was to examine the body tissue composition and functional traits of young football players. **Methods.** Analysis was performed on 23 junior football players. Body mass and height were measured. Bioelectrical impedance was used to assess the players' body composition (fat mass, muscle mass, body cell mass and extracellular mass). The body mass index, body cell mass index and the extracellular mass/body cell mass ratio were also calculated. Functional traits were assessed by a one-on-one football game in an enclosed space with the objective to score the highest number of goals in a timed setting. Measurements of HR_{rest}, HR_{max} and heart rate reserve were used to evaluate the efficiency of the subjects' cardiovascular systems. **Results.** Insignificant differences in body tissue composition and cardiovascular efficiency were found regardless of what position was played. Overall, forwards were characterised by having the greatest height, the highest level of active body tissue development and the most efficient cardiovascular systems. Defenders were characterised by having larger body build, while midfielders displayed a significantly greater percentage of extracellular mass and EMC in relation to BCM. **Conclusions.** The results reveal that trends exist in the body tissue composition and cardiovascular efficiency of football players depending on which position they play. These differences reflect the varied physical efforts players perform during a match and should be taken into consideration when designing training programmes.

Key words: body composition, heart rate, football

Introduction

The game of football requires players to perform periodically under high intensity by using aerobic energy sources that sometimes involves overloading the neuromuscular and hormonal systems. The ability of the neuromuscular system to produce maximum power in the lower extremities is particularly important for football players, since the ability to produce explosive efforts at maximum power and force together with a high contraction velocity seems to be one of the main physiological features which differentiate players at different training levels [1, 2]. On the other hand, the variation of sprint activity among football players is reflected in the variety of physiological responses players' bodies produce. Results have shown that high intensity aerobic interval training leads to an increase in VO_{2max} without negative interference effects on strength, jumping ability or sprint performance [3].

One of the most informative and easiest to examine parameters is heart rate, which characterises the efficiency of the cardiovascular system [4]. Research has shown that whole-day heart rate monitoring is an objective, unobtrusive method for measuring physical activity at the age of puberty. For athletes in training, these data are commonly collected from the monitoring of heart rate changes and used to prevent the occurrence of fatigue [5]. It is commonly known that athletes performing to a high degree are characterised by an improved lowering of their resting heart rate (HR_{rest}). Furthermore, the correlations observed between maximum heart rate (HR_{max}), reflected as the highest heart rate achieved during exercise, and HR_{rest} have been used to create an index that can compute VO_{2max} [6]. This research revealed that the absolute and relative values of maximum heart rate and oxygen absorption were higher in young elite players in comparison to their peers at a lower training level [7]. In amateur football, the recording of HR was confirmed to be useful for training purposes and was also applied to characterise metabolic expenditure during physical effort [8].

Furthermore, with regard to young players, the influence of puberty on body height and functional capacity have also been well substantiated. Children and youth performing sports, in comparison to their non-exercising peers, displayed greater development of their somatic features, body efficiency and physical fitness [9]. Studies performed on pubertal youths indicate that the level of biological maturity influences the variation of development regarding physical efficiency, velocity and strength. The period of greatest body growth is frequently followed by a significant rise in static and explosive force development. Analogous changes in VO_{2max} have been found to accompany the pubertal spurt of body height [10]. The application of multiple linear regres-

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sion analysis revealed the existence of a significant relationship between maturity advancement, growth and composite football skill scores in a group of football players at the age of puberty [11]. Positive regression coefficients were obtained for the occurrence of puberty and aerobic resistance. However, the coefficient for body height was negative, indicating the role of a lower centre of gravity in better football skill performance. However, Philippaerts et al. [12] observed that the period during the greatest height spurt coincides with the development of maximum balance ability, explosive force, running speed, upper-body muscular endurance, agility, cardiorespiratory endurance and anaerobic capacity. A plateauing of explosive force development, upper-body muscular endurance and running speed was observed after the pubertal height spurt, at which point body flexibility increasingly developed.

Body tissue composition constitutes one of the factors that not only determine athletes' motor fitness and sport level but also plays a role in training. Moreover, it varies tremendously across individuals in regards to age and body build. In this regard, adolescence is a very important phase in life due to various social factors that adolescents face and the numerous neuro-hormonally determined changes that affect body tissue composition. This includes the influence of growth hormone, which has, among others, been found to be of significant importance in the maturation of lean mass and muscle strength development at puberty and for young adults in general [13]. The results of research also indicate that a relationship exists between fat (determined by anthropometric measurement) and the beginning of puberty in both genders. In the case of young football players, development of choice body tissue components (lean tissue) has been noted as the result of improved physical performance [14, 15].

The development of adolescent boys is, in particular, characterised by an overall decrease in fat tissue and increase in BMI, which at this age reflects an increase in lean mass [16]. Youth involvement in sport (e.g. football) has also been credited in stimulating bone mass development. However, longitudinal research on a cadet football league (youths aged 11–14) did not reveal any acceleration in their morphological development, although it was revealed that muscle power, especially agility and coordination, distinguished the young football players from their untrained peers [17]. Therefore, in order further to investigate this issue, this study examined the features of body tissue composition and functional traits of a group of young 2nd league football players.

Material and methods

Twenty-three junior football players playing on a 2nd league team from Wrocław, Poland were recruited. The players' mean age was 16.2 years (± 0.70) and had mean training period of 7.3 years (± 1.87). The university's research ethics committee approved the study and all participants provided their written informed consent prior to data collection, which took place at the end of the 2009 competitive season. Information regarding what position they played in was obtained from their coach.

Body mass and height were measured and used to calculate body mass index (BMI; body mass [kg]/body height [m]^2). Body composition was assessed by bioelectrical impendance with a BIA-101/S analyser (tetrapolar version, electrodes placed on the hand–foot) integrated with Bodyimage 1.31 software (Akern, Italy). Body composition was measured before an exercise test, with fat mass (FM), muscle mass (MM), body cell mass (BCM) and extracellular mass (ECM) recorded. The components of body composition were expressed in kilograms or percentage of body mass. Body composition measurements were used to compute the body cell mass index (BCMI = BCM [kg] / body height [m]^2) and the ratio of ECM/BCM (extracellular mass/body cell mass).

The players' functional abilities were measured in special test conditions in order to promote high-intensity exercise: individual players participated in a three-minute game of one-on-one football within an enclosed, circular cage (a diameter of 500 cm with 250 cm walls) with goals located on both sides (Hattrick Cage, Ludus Partner, Poland). The aim of the game was to score the highest number of goals. Resting heart rate (HR_{rest}) was measured prior to the test, while maximum heart rate (HR_{max}) was measured immediately after each game. Heart rate was monitored and analysed with a short-range telemetry system (Polar Electro Oy, Finland). Heart rate reserve (HRR) was computed by subtracting HR_{rest} from HR_{max}.

Statistica version 9.0 for Windows (StatSoft Inc., USA) was used for statistical analysis. Basic statistical characteristics were computed (mean, standard deviation). The Shapiro-Wilk's test was used to evaluate normal distribution. One-way between-groups analysis of variance (ANOVA) with Tukey's *post hoc* test was used to evaluate the variation of the values recorded for body tissue composition and the physiological features among the participants depending on their position (forwards $n = 7$, midfielders $n = 9$, defenders $n = 7$). Statistical significance was set at $p \leq 0.05$.

Results

The anthropometric characteristics and functional abilities of the football players are presented in Table 1. The Shapiro-Wilk's test indicates that body height and mass and the studied components of body composition and the players' physiological response present normal distribution. Analysis of variance, applied to evaluate the variation of the analysed features between those playing as forwards, midfielders and defenders, did not reveal any statistically significant differences (Tab. 2) except for the percentage of extracellular mass between forwards and midfielders.

The results find that forwards are characterised by the highest body height, body cell mass, muscle mass and fat mass. HR_{max} and HRR values were also at a high level. Furthermore, forwards displayed the lowest levels of extracellular mass development, ECM/BCM and resting heart rate. Furthermore, the BMI and BCMI indices indicate that forwards had the largest body build as well as exhibiting the highest HR_{max}. When compared with the other positions, their BCM percentage, muscle mass and heart rate reserve were at lower levels. Overall, midfielders displayed the smallest body size. This group also exhibited the lowest level of body fat and BMI and BCMI values. Their HR_{max} values were the lowest compared with the other positions. However, when compared with forwards and defenders, midfielders were characterised by a significantly greater amount of extracellular body mass and larger values of the ECM/BCM index.

Table 1. Physical characteristics of the junior football players (N = 23)

Variable	Mean	SD
Body mass (kg)	66.0	5.62
Body height (cm)	173.7	3.69
Fat mass (kg)	10.4	2.64
Body cell mass (kg)	32.6	2.92
Extracellular mass (kg)	22.9	2.25
Muscle mass (kg)	39.7	3.41
Fat mass (%)	15.7	3.29
Body cell mass (%)	49.5	2.90
Extracellular mass (%)	34.8	2.53
Muscle mass (%)	60.3	3.17
BMI ($kg \cdot m^{-2}$)	21.9	1.36
BCMI ($kg \cdot m^{-2}$)	10.8	0.88
ECM/BCM	0.7	0.07
HR_{rest} ($b \cdot min^{-1}$)	78.96	12.05
HR_{max} ($b \cdot min^{-1}$)	181.26	10.40
HRR ($b \cdot min^{-1}$)	102.30	13.43

Discussion

The specificity of modern sport necessitates taking into consideration certain body build predispositions in order to determine what somatic criteria ought to be used when selecting potential athletes in given sport. The optimum adaptation of an athlete to the requirements of the sport they play in is in large part the result of their morphological structure and a targeted training regimen that modifies selected somatic parameters. For young athletes, in addition to the above factors, puberty also plays a large role in promoting significant changes in body morphology and tissue composition [18]. This period is characterised by an increase in height, mass, lean mass and bone mineral content. When compared with girls, the fat content of boys is at a lower level, where this predisposition is also reinforced by the large-scale involvement of young boys in sport. Although the physical load youths undergo depends on the sport, most training is sufficient enough to cause characteristic changes in the development level of various body com-

Table 2. Physical characteristics of the junior football players grouped by playing position (mean ± SD)

Variable	Playing position: Forwards (n = 7)	Midfielders (n = 9)	Defenders (n = 7)	p
Body mass (kg)	67.21 ± 5.46	63.77 ± 6.30	67.57 ± 4.58	0.332
Body height (cm)	175.53 ± 2.28	172.67 ± 4.47	173.36 ± 3.54	0.302
Fat mass (kg)	11.39 ± 2.24	9.06 ± 2.37	11.19 ± 2.93	0.140
Body cell mass (kg)	33.51 ± 3.27	31.49 ± 2.95	33.20 ± 2.39	0.333
Extracellular mass (kg)	22.31 ± 2.23	23.22 ± 2.66	23.19 ± 1.86	0.700
Muscle mass (kg)	40.70 ± 3.71	38.36 ± 3.52	40.40 ± 2.79	0.331
Fat mass (%)	16.91 ± 2.76	14.11 ± 3.08	16.40 ± 3.64	0.189
Body cell mass (%)	49.88 ± 2.85	49.49 ± 3.16	49.19 ± 3.02	0.914
Extracellular mass (%)	33.22 ± 2.16*	36.42 ± 1.82	34.38 ± 2.72	0.028
Muscle mass (%)	60.59 ± 2.99	60.29 ± 3.58	59.87 ± 3.25	0.921
BMI ($kg \cdot m^{-2}$)	21.83 ± 1.69	21.40 ± 1.12	22.49 ± 1.23	0.299
BCMI ($kg \cdot m^{-2}$)	10.89 ± 1.10	10.54 ± 0.69	11.06 ± 0.90	0.513
ECM/BCM	0.67 ± 0.07	0.74 ± 0.07	0.70 ± 0.08	0.174
HR_{rest} ($b \cdot min^{-1}$)	77.14 ± 14.75	77.33 ± 7.43	82.86 ± 14.70	0.612
HR_{max} ($b \cdot min^{-1}$)	196.00 ± 11.75	191.33 ± 7.02	193.00 ± 9.61	0.668
HRR ($b \cdot min^{-1}$)	104.14 ± 17.33	101.78 ± 7.85	101.14 ± 16.53	0.914

* significantly different from midfielders ($p < 0.05$)

position and functional features. For example, a study of young prepubertal football players revealed a decrease in body fat and an increase in lean body and bone mineral content in comparison with their control group peers [19]. A significant increase in bone mineral content around the femur neck and lumbar spine areas was also observed in male adults practicing recreational football for many years [20].

When comparing playing positions, body composition analysis on adult football players found observable differences between goalkeepers and outfield players [21]. Regarding youth, all players aside from goalkeepers revealed little difference in the development of their body composition. The results indicate that the lowest amount of fat tissue is observed in midfielders, although similar values were noted for forwards and defenders. However, greater variation of fat tissue levels has been revealed in adult players [22]. Significantly greater fat mass was discernible in midfielders in comparison with forwards and defenders.

Lean body mass consists of body cell mass, extracellular fluid and extracellular solids [23]. Body cell mass, which is the mass of all metabolically active body cell components, plays a significant role in physical training. Chronic diseases such as AIDS, tumours or cancers and the ageing process all result in a decrease of BCM. The metabolic activity of BCM and its significant role in the human body is also evident in how diversified its development is, although depending on the physical activity an individual performs and their training level [24]. The results confirm previous studies that have indicated an insignificant variation in the somatic structure and body composition of outfield players in relation to players in other positions [25]. The largest BCM and muscle mass values are observed in forwards while the lowest in defenders. Melchiorri et al. [26] observed a similar trend by analysing the body composition of two professional male football teams from two different divisions. The higher ranked team displayed significantly lower levels of body fat in its defenders, while higher BCM values were noted among the forwards from both teams. Players who were individually ranked higher displayed greater cell mass, even though the two teams differed in age, body mass, height and BMI.

The players analysed in this study did not display significant differences in body mass and tissue composition. Previous research has confirmed a correlation between athletes' BMI and creatinine concentration although this is dependent on the practiced sport, type of training, involvement of aerobic and anaerobic metabolism and the length of the competitive season [27]. Nevertheless, other research on athletes of both genders and people with eating disorders indicated that body cell mass index, in comparison to BMI, is better suited to monitor changes in the amount of muscle mass [28]. This results from the fact that the body cell mass index is more sensitive to changes in the nutritional status of an individual. In the examined group of footballers, the lowest values of both indices were observed in midfielders, while defenders displayed the greatest body mass and cell mass when taking body height into consideration. The obtained results may be further justified by the observed ascendency of the mesomorphic somatotype of defenders [29].

Extracellular mass contains all the metabolically inactive body tissues, and thus an increased ECM/BCM index value is frequently interpreted as a sign of malnutrition. However, a different trend is observed among football players, who feature a decrease in the relative amount of extracellular mass [30]. This has been linked to physical activity that requires larger power output, such as in endurance running and cross country skiing. In the group of football players examined in this study, the overall ECM/BCM index was found to be 0.7, which corresponds to those values in well-trained adult competitors [31]. When considering playing positions, the lowest index value was observed in forwards, while midfielders were characterised by the highest level of extracellular mass in relation to cell mass.

The easiest way to measure the reaction of the cardiovascular system to effort is to determine the heart rate index, which has been significantly correlated to VO_{2max} and blood lactate and saliva lactate levels. Heart rate reserve is also used as an indirect measurement of the intensity of metabolic changes and useful when comparing the endurance of players in different positions on the pitch [32]. The group of youth football players analysed in this study featured no statistically significant variation between resting heart rate, maximum heart rate or heart rate reserve. However, it should be emphasised that forwards displayed the lowest HR_{rest} and the highest HR_{max} and HRR during the test. Defenders were characterised by the highest values of resting heart rate and the lowest values of maximum heart rate and heart rate reserve. Based on the obtained results, it can be concluded that forwards are characterised by the highest level of cardio-vascular efficiency. Research conducted on 14–21 year-old football players revealed that forwards were characterised by greater endurance, velocity, agility and power, along with better muscle development and body leanness, than other players [33]. Goalkeepers, on the other hand, were characterised with greater height, mass, body fat and the lowest aerobic capacity. Midfielders displayed greater levels of agility and endurance, while defenders were characterised by the lowest body fat.

Conclusions

Analysis of the results revealed that there are certain differentiating trends in body tissue composition and cardiovascular efficiency among football players playing in different positions. Forwards were characterised by having the greatest height, highest levels of active body tissue development and the most efficient cardiovascular systems. Defenders displayed larger body build, while midfielders were characterised by significantly higher values of extracellular mass and EMC in relation to BCM. These differences reflect the varied physical efforts players perform during a match and should be taken into consideration when designing training programmes.

References

1. Wisloff U., Helgerud J., Hoff J., Strength and endurance of elite soccer players. *Med Sci Sports Exerc*, 1998, 30, 462–467.
2. Gorostiaga E.M., Izquierdo M., Ruesta M., Iribarren J., González-Badillo J.J., Ibáñez J., Strength training effects on physical performance and serum hormones in young soccer players. *Eur J Appl Physiol*, 2004, 91, 698–707, doi: 10.1007/s00421-003-1032-y.
3. McMillan K., Helgerud J., Macdonald R., Hoff J., Physiological adaptations to soccer specific endurance training in professional youth soccer players. *Br J Sports Med*, 2005, 39, 273–277, doi: 10.1136/bjsm.2004.012526.
4. Tanaka H., Monahan K.D., Seals D.R., Age-predicted maximal heart rate revisited. *J Am Coll Cardiol*, 2001, 37, 153-156, doi: 10.1016/S0735-1097(00)01054-8.
5. Bricout V.-A., Dechenaud S., Favre-Juvin A., Analyses of heart rate variability in young soccer players: The effects of sport activity. *Auton Neurosci*, 2010, 154, 112–116, doi: 10.1016/j.autneu.2009.12.001.
6. Uth N., Sørensen H., Overgaard K., Pedersen P.K., Estimation of VO_{2max} from the ratio between HR_{max} and HR_{rest} – the Heart Rate Ratio Method. *Eur J Appl Physiol*, 2004, 91, 111–115, doi: 10.1007/s00421-003-0988-y.
7. Strøyer J., Hansen L., Klausen K., Physiological profile and activity pattern of young soccer players during match play. *Med Sci Sports Exerc*, 2004, 36, 168–174, doi: 10.1249/01.MSS.0000106187.05259.96.
8. Esposito F., Impellizzeri F.M., Margonato V., Vanni R., Pizzini G., Veicsteinas A., Validity of heart rate as an indicator of aerobic demand during soccer activities in amateur soccer players. *Eur J Appl Physiol*, 2004, 93, 167–172, doi: 10.1007/s00421-004-1192-4.
9. Burdukiewicz A., Janusz A., Physical capacity and fitness of children and youths as related to their somatic development. *Biol Sport*, 1995, 12, 175–188.
10. Malina R.M., Eisenmann J.C., Cumming S.P., Ribeiro B., Aroso J., Maturity-associated variation in the growth and functional capacities of youth football (soccer) players 13–15 years. *Eur J Appl Physiol*, 2004, 91, 555–562, doi: 10.1007/s00421-003-0995-z.
11. Malina R.M, Ribeiro B., Aroso J., Cumming S.P., Characteristics of youth soccer players aged 13–15 years classified by skill level. *Br J Sports Med*, 2007, 41, 290–295, doi: 10.1136/bjsm.2006.031294.
12. Philippaerts R.M., Vaeyens R., Janssens M., van Renterghem B., Matthys D., Craen R. et al., The relationship between peak height velocity and physical performance in youth soccer players. *J Sports Sci*, 2006, 24, 221–230, doi: 10.1080/02640410500189371.
13. Hulthén L., Bengtsson B.-Å., Sunnerhagen K.S., Hallberg L., Grimby G., Johannsson G., GH is needed for the maturation of muscle mass and strength in adolescents. *J Clin Endocrinol Metab*, 2001, 86, 4765–4770, doi: 10.1210/jc.86.10.4765.
14. Silvestre R., West C., Maresh C.M., Kraemer W.J., Body composition and physical performance in men's soccer: A study of A National Collegiate Athletic Association Division Iteam. *J Strength Cond Res*, 2006, 20, 177–183, doi: 10.1519/R-17715.1.
15. Pantelis T. N., Anaerobic Power across Adolescence in Soccer Players. *Hum Mov*, 2011, 12 (4), 342–347, doi: 10.2478/v10038-011-0039-1.
16. Maynard L.M., Wisemandle W., Roche A.F., Chumlea W.C., Guo S.S., Siervogel R.M., Childhood body composition in relation to Body Mass Index. *Pediatrics*, 2001, 107, 344–350, doi: 10.1542/peds.107.2.344.
17. Mirkov D.M, Kukolj M., Ugarkovic D., Koprivica V.J., Jaric S., Development of anthropometric and physical performance profiles of young elite male soccer players: A longitudinal study. *J Strength Cond Res*, 2010, 24, 2677–2682, doi: 10.1519/JSC.0b013e3181e27245.
18. Bale P., Mayhew J.L., Piper F.C., Ball T.E., Willman M.K.J., Biological and performance variables in relation to age in male and female adolescent athletes. *J Sports Med Phys Fitness*, 1992, 32, 142–148.
19. Vicente-Rodríguez G., Ara I., Perez-Gomez J., Serrano-Sanchez J.A., Dorado C., Calbet J.A.L., High femoral bone mineral density accretion in prepubertal soccer players. *Med Sci Sports Exerc*, 2004, 36, 1789–1795.
20. Calbet J.A.L., Dorado C., Díaz-Herrera P., Rodríguez-Rodríguez L.P., High femoral bone mineral content and density in male football (soccer) players. *Med Sci Sports Exerc*, 2001, 33, 1682–1687, doi: 10.1097/00005768-200110000-00011.
21. Sutton L., Scott M., Wallace J., Reilly T., Body composition of English Premier League soccer players: Influence of playing position, international status, and ethnicity. *J Sports Sci*, 2009, 27, 1019–1026, doi: 10.1080/02640410903030305.
22. Wittich A., Oliveri M.B., Rotemberg E., Mautalen C., Body Composition of Professional Football (Soccer) Players Determined by Dual X-Ray Absorptiometry. *J Clin Densitom*, 2001, 4, 51–55.
23. Wang Z.M., Heshka S., Wang J., Gallagher D., Deurenberg P., Chen Z. et al., Metabolically active portion of fat-free mass: a cellular body composition level modeling analysis. *Am J Physiol Endocrinol Metab*, 2007, 292, 49–53, doi: 10.1152/ajpendo.00485.2005.
24. Andreoli A., Melchiorri G., Brozzi M., Marco A., Volpe S.L., Garofano P. et al., Effect of different sports on body cell mass in highly trained athletes. *Acta Diabetol*, 2003, 40, S122–S125, doi: 10.1007/s00592-003-0043-9.
25. Hazir T., Physical characteristics and somatotype of soccer players according to playing level and position. *J Hum Kinet*, 2010, 26, 83–95, doi: 10.2478/v10078-010-0052-z.
26. Melchiorri G., Monteleone G., Andreoli A., Callà C., Sgroi M., De Lorenzo A., Body cell mass measured by bioelectrical impedance spectroscopy in professional football (soccer) players. *Sports Med Phys Fitness*, 2007, 47, 408–412.
27. Banfi, G., Del Fabbro M., Relation between serum creatinine and body mass index in elite athletes of different sport disciplines. *Br J Sports Med*, 2006, 40 (8), 675–678, doi: 10.1136/bjsm.2006.026658.
28. 28. Talluri A., Liedtke R., Mohamed E.I., Maiolo C., Martinoli R., De Lorenzo A., The application of body cell mass index for studying muscle mass changes in health and disease conditions. *Acta Diabetol*, 2003, 40, S286–S289, doi: 10.1007/s00592-003-0088-9.

29. Orhan Ö., Sağir M., Zorba E., Kishali N. F., A comparison of somatotypical values from the players of two football teams playing in Turkcell Turkish super league on the basis of the players' positions. *J Phys Educ Sport Manag*, 2010, 1, 1–10.
30. Randáková R., Effect of regular training on body composition and physical performance in young cross-country skiers: as compared with normal controls. *Acta Univ Palacki Olomuc Gymn*, 2005, 35, 17–35.
31. Bunc V., Body composition as a determining factor in the aerobic fitness and physical performance of Czech children. *Acta Univ Palacki Olomuc Gymn*, 2006, 36, 39–45.
32. Impellizzeri F.M., Rampinini E., Marcora S.M., Physiological assessment of aerobic training in soccer. *J Sports Sci*, 2005, 23, 583–592, doi: 10.1080/02640410400021278.
33. Gil S.M., GIL J., Ruiz F., Irazusta A., Irazusta J., Physiological and anthropometric characteristics of young soccer players according to their playing position: Relevance for the selection process. *J Strength Cond Res*, 2007, 21, 438–445, doi: 10.1519/R-19995.1.

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