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Body Composition Differences in Elite Young Soccer Players Based on Playing Position

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ABSTRACT The purposes of this study were to compare anthropometric and body compositions (BC) parameters and to identify morphological asymmetries related to the playing position in 104 elite youth soccer players. The following parameters were measured by whole-body bioelectrical impedance analysis: Body Height (BH), Body Mass (BM), Lean Body Mass (LBM), relative Lean Body Mass (LBMr), percentage of Fat Mass (FM), the ratio of Extra Cellular Mass to Body Cell Mass (ECM/BCM), segmental proportion of muscle mass in upper extremities, trunk, lower extremities and percentage differences between the upper (ΔUE) and lower (ΔLE) extremities. The criterion of "playing position" had a significant effect on all of the screened variables except ECM/BCM, FM, LBMr, and ΔUE ($p>0.05$). There was detected significant differences in ΔLE with respect to playing positions ($F_{(5,98)}$= 6.53, $p<0.01$, ç^2=0.25). Research has shown differences between anthropometric indicators and BC variables in players of different playing positions.

INTRODUCTION

During a soccer match, a player's movements are characterized by high-intensity, short-term actions and rest periods of varying length (Rogan et al. 2011). Optimal soccer performance is determined by the appropriate timing of the optimal level of technical, tactical and physical characteristics and their combination at any given moment. Certain body composition (BC) parameters are important to a soccer player's performance. Success in athletics has been associated also with specific anthropometric characteristics, body composition and somatotype (Duquet and Carter 2001). Excessive fat mass acts as inactive mass, which does not participate in active movement, acceleration or kicking. A higher amount of fat mass significantly decreases power and sprinting performance and is inversely correlated with endurance and agility (Gil et al. 2005) and is connected with faster onset of fatigue during aerobic and intermittent activities (Krzykala et al. 2016). It is also well known, that body fat levels affect energy expenditure and a player's power-to-weight ratio and acceleration capacity (Duthie et al. 2003). Conversely, lean body mass strongly contributes to strength and power performance (Milanese et al. 2015).

Earlier studies have analysed different representations of these components (active and inactive mass) in relation to the energetic demands of a soccer match and the diversity of BC variables in the individual field positions of soccer (Almagia et al. 2015). Some studies have presented an optimal level of muscle mass in youth soccer players as a standard in order to be considered for professional competition with senior players (Aguilera et al. 2012) and to build versatility among professional and non-professional teams (Almagia et al. 2015; Milsom et al. 2015). Furthermore, body composition has been observed in terms of morphological asymmetries, and the resulting maladaptive effects that may influence some components of physical fitness in young and adult populations. Because soccer skills are executed asymmetrically at irregular intervals by players at various positions (fullbacks, wide midfielders vs. central defenders, central midfielders, attackers and goalkeepers), we might expect morphological and physiological asymmetry as a result of position-specific adaptations. A high level of asymmetry has been associated with injury risk in young and adult athletes (Bak

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and Magnusson 1997). Asymmetry between the dominant and non-dominant sides or left and right sides has often been evaluated on the basis of morphological (Mala et al. 2011) or strength properties (Fousekis et al. 2010). Maly et al. (2016) reported that more than 73.2 percent of youth soccer players had at least one strength asymmetry of knee extensors, or flexors (unilateral, bilateral strength ratio).

The goals of this study were to compare anthropometric parameters and body compositions and to identify morphological asymmetries related to the playing position in youth Czech soccer players.

METHODOLOGY

Study Sample

The monitored players (n = 104, age 18.2±0.6 years) of the highest youth Czech league (U19) were divided according to playing positions into: goalkeepers (GK: n = 11, age 18.5±0.4 years), fullbacks (FB: n = 23, age 18.2±0.5 years), central defenders (CD: n = 14, age 18.4±0.4 years), wide midfielders (WM: n = 19, age 18.2±0.5 years), central midfielders (CM: n = 22, age 18.6±0.3 years), and attackers (AT: n = 15, age 18.8±0.2 years). Testing took place at the beginning of the pre-season training period in laboratory conditions. The players were informed about the measurement procedures and they signed an informed consent form.

Body Composition Assessment

The participants were tested between 8:00–9:00 a.m. under standardized conditions (Kyle et al. 2004; Mala et al. 2015). They did not consume alcohol, caffeine or other medicaments that could have influenced the results 24 hours prior to measurement. They were also asked to not eat any food or drink liquids before measurement. Moreover, the tested players did not perform any high intensity physical activity 2 days prior to measurement. Body mass (BM) was measured by a digital scale (SECA 769, Hamburg, Germany) and body height (BH) by a digital stadiometer (SECA 242, Hamburg, Germany).

Body composition was examined using whole-body bioelectrical impedance with the phase-sensitive whole-body tetrapolar bioelectrical impedance measurement device BIA 2000M (Data Input GmbH, Germany) and Tanita MC-980MA (Tanita Corporation, Japan). The following parameters were observed: Body Height (BH), Body Mass (BM), Lean Body Mass (LBM), relative Lean Body Mass (LBMr), percentage of Fat Mass (FM), the ratio of Extra Cellular Mass to Body Cell Mass (ECM/BCM), as well as segmental proportion of muscle mass in upper extremities, trunk, lower extremities and percentage differences between the upper extremities (ΔUE) and lower extremities (ΔLE).

Statistical Analysis

From methods of descriptive statistics, it was used the mean as a measure of central tendency and standard deviation as measures of variability. Data are expressed as mean±standard deviation (M ± SD). Multilevel analysis of variances, Bonferroni *post hoc* test, and partial eta square (η_p^2) were used for statistical assessment. The rejection of the null hypothesis was assessed at the level of $p \leq .05$. Statistical analysis was performed using IBM® SPSS® v21 (Statistical Package for Social Science, Inc., Chicago, IL, 2012).

RESULTS

Multilevel analysis of variance revealed significant differences in the means of the selected variables between the observed groups (field positions) ($F_{(65.410)} = 2.06$, $\lambda = 0.26$, $p < 0.01$, $\eta^2 = 0.23$). The criterion of "playing position" had a significant effect on all of the screened variables except ECM/BCM, Fat Mass, LBMr, and ΔUE (upper extremities) ($p > 0.05$) (Table 2). Fullbacks and wide midfielders are significantly smaller and lighter in comparison to other field position players ($p < 0.01$) (Table 1). It was detected significant differences in the segmental muscle mass distribution in the lower extremities (ΔLE – lower extremities) with respect to the various field positions ($F_{(5.98)} = 6.53$, $p < 0.01$, $\eta^2 = 0.25$). Significant differences were also found in fullbacks (3.54±1.20%) and wide midfielders (3.58 ± 1.39%), in comparison to central defenders (2.19 ± 1.11%), attackers (2.04±1.62%) and goalkeepers (1.14± 0.96%).

DISCUSSION

The data analysis showed that goalkeepers were the tallest and heaviest players in this study.

Table 1: Basic anthropometric characteristics and body composition parameters in players according to their field positions (mean ± standard deviation)

Variables	*GK (n=11)*	*FB (n=23)*	*CD (n=14)*	*WD (n=19)*	*CD (n=22)*	*AT (n=15)*
Body height (cm)	189.72(5.59)	175.26(3.80)	183.16(6.06)	180.70(6.39)	177.52(5.27)	181.32(5.39)
Body mass (kg)	82.47(4.83)	68.91(2.89)	76.69(10.08)	72.19(6.49)	71.72(4.71)	76.02(6.37)
ECM/BCM	0.76(0.07)	0.71(0.06)	0.74(0.05)	0.72(0.05)	0.72(0.05)	0.73(0.05)
Fat mass (%)	10.96(1.25)	10.40(1.06)	10.33(2.62)	9.78(1.61)	10.42(1.75)	11.68(2.70)
Lean body mass (kg)	72.97(5.20)	61.75(2.24)	68.51(7.30)	65.04(5.30)	63.57(2.94)	67.02(5.75)
Rel. lean body mass	0.89(0.02)	0.90(0.01)	0.90(0.03)	0.90(0.02)	0.90(0.05)	0.88(0.03)
Preferred leg (l)	12.02(0.99)	10.44(0.66)	11.49(1.11)	10.89(0.99)	10.77(0.66)	11.25(1.03)
Non-preferred leg (l)	11.94(1.01)	10.07(0.65)	11.13(1.20)	10.62(1.06)	10.39(0.65)	11.03(1.06)
ΔUE (%)	1.14(0.96)	3.54(1.20)	2.19(1.11)	2.53(1.48)	3.58(1.39)	2.04(1.62)
Trunk (l)	37.53(2.82)	31.14(1.54)	34.71(3.78)	33.10(3.13)	31.67(1.76)	34.37(2.61)
Preferred arm (l)	4.39(0.67)	3.33(0.46)	3.76(0.65)	3.60(0.73)	3.54(0.45)	3.73(0.61)
Non-preferred arm (l)	4.31(0.61)	3.37(0.44)	3.78(0.65)	3.57(0.64)	3.52(0.42)	3.77(0.59)
ΔLE (%)	2.63(2.29)	2.01(1.76)	1.48(1.35)	2.82(2.80)	2.14(2.06)	1.91(1.88)

Note: ECM/BCM – extracellular-intracellular mass ratio, ΔUE – percentage differences between the upper extremities, ΔLE – percentage differences between the lower extremities, l – liter.

Table 2: Statistical significance in the screened parameters with regard to players' playing positions

Variables	*Sum of sq.*	*F*	*Sig.*	*Eta sq.*	*Post-hoc*
Body height (cm)	1863.72	12.89	0	0.4	GK vs. FB,CD,WM,CM,AT; FB vs. GK, CD, WM,AT; CD vs GK,FB,CM; WM vs. GK, FB, CM; CM vs. GK,CD,AT; AT vs. GK,FB,CM
Body mass (kg)	1707.65	9.48	0	0.33	GK vs. FB,CD,WM,CM,AT; FB vs. GK, CD,AT; CD vs GK,FB,WM,CM; WM vs. GK, CD; CM vs. GK,CD,AT; AT vs. GK,FB, CM
ECM/BCM	0.03	1.69	0.15	0.08	
Fat mass (%)	33.43	1.91	0.1	0.09	
Lean body mass (kg)	1184.34	10.44	0	0.35	GK vs. FB,CD,WM,CM,AT; FB vs. GK, CD,WM,AT; CD vs GK,FB,WM,CM; WM vs. GK, FB,CD; CM vs. GK,CD,AT; AT vs. GK, FB,CM
Rel. lean body mass	0	1.18	0.32	0.06	
Preferred leg (l)	24.36	6.19	0	0.24	GK vs. FB,WM,CM,AT; FB vs. GK,CD,AT; CD vs. FB,CM; WM vs. GK; CM vs. GK,CD; AT vs. GK,FB
Non-preferred leg (l)	32.52	7.71	0	0.28	GK vs. FB,CD,WM,CM,AT; FB vs. GK, FB, AT; CD vs GK,FB,CM; WM vs. GK; CM vs. GK,CD,AT; AT vs. GK,FB, CM
ΔUE (%)	68.14	6.53	0	0.25	GK vs. FB,CD,WM,CM,AT; FB vs. GK, WM, AT; CD vs GK, AT; WM vs. GK,FB,CM; CM vs. GK,WM,AT; AT vs. FB,CD,CM
Trunk (l)	408.15	12.22	0	0.38	GK vs. FB,CD,WM,CM,AT; FB vs. GK, CD,WM,AT; CD vs GK,FB,WM,CM; WM vs. GK, FB; CM vs. GK,CD,AT; AT vs. GK,FB, CM
Preferred arm (l)	8.92	5.21	0	0.21	GK vs. FB,CD,WM,CM,AT; FB vs. GK, CD,AT; CD vs GK,FB; WM vs. GK; CM vs. GK; AT vs. GK,FB
Non-preferred arm (l)	7.61	5.08	0	0.21	GK vs. FB,CD,WM,CM,AT; FB vs. GK, CD,AT; CD vs GK,FB; WM vs. GK; CM vs. GK; AT vs. GK,FB
ΔLE (%)	19.48	0.88	0.5	0.04	

Note: ECM/BCM – extracellular-intracellular mass ratio, ΔUE – percentage differences between the upper extremities, ΔLE – percentage differences between the lower extremities, l – liter, GK – goalkeepers, FB – fullbacks, CD – central defenders, WM – wide midfielders, CM – central midfielders, AT – attackers.

In contrast, the central midfielders and fullbacks were the smallest and lightest ($p < 0.01$) players. This result is consistent with the available literature (Bangsbo and Michalsik 2002; Gil et al. 2007; Reilly et al. 2000; Milsom et al. 2015). The recorded differences in body height and weight or in somatotypes and body indices can already be used in youth categories as the only one of tools for talent identification in soccer; however, the lack of information about the quality of the body composition must be considered.

All of the recorded values for lean body mass are at the level of elite athletics, and our observed soccer players had a higher percentage of muscle tissue compared to the general population, ranging as high as sixty-two percent of their total body mass (Reilly et al. 2000). The absolute values indicate a significantly higher proportion of lean body mass and total body mass in goalkeepers than in the other field positions ($p < 0.01$). According to Gil et al. (2007), goalkeepers (non-professionals, 14 – 21 years, n = 21) had a significantly higher absolute amount of lean body mass than midfielders, attackers and defenders ($p < 0.05$). According to Santi-Maria et al. (2015), goalkeepers (professional, n = 163, 15.1±2.4 years) had a higher absolute amount of lean body mass than attackers and midfielders. The highest absolute amount of lean body mass was recorded in defenders. An insignificant difference in the relative amount of lean body mass among the observed players indicates the comparable predispositions for muscle work in players of different field positions and the need for making the absolute values relative to body weight when comparing individuals. Similarly, the index of extracellular and intracellular mass did not indicate a greater predisposition for muscle work in different field positions ($p > 0.05$). The ECM/BCM ratios showed values recommended for elite athletics in all of the monitored athletes (Dörhöfer and Pirlich 2007). Despite the fact that the ECM/BCM ratio is largely stable and genetically determined, the monitoring of lean body mass components (intra- and extracellular mass) is useful when trying to record changes over a shorter time period (short-term intervention, monitoring changes after injury during recovery, monitoring hydration changes during a match).

Presented data did not reveal any significant differences in fat mass proportion, what is in line with Semjon et al. (2016) who reported non-significant differences between goalkeepers (11.5 ± 3.1 %) compare to fullbacks (11.2 ± 2.4 %), central defenders (11.7 ± 2.8 %), wide midfielders (10.3 ± 2.1 %), central midfielders (9.9 ± 2.9 %) and attackers (10.4 ± 3.1 %). Conversely, the some papers presents goalkeepers as the position players with the highest proportion of fat (Gil et al. 2007; Sporis et al. 2009; Mala et al. 2015). This result may be because modern soccer requires a goalkeeper to execute fast and explosive actions (jumps, diving, fast changes of direction) and change their centre of gravity within a larger operating area where the goalkeepers approach the outfield players. Milsom et al. (2015) presented the diversity of fat mass proportions in the tested players. The authors presented an average of ten percent fat mass in professional soccer players (n = 83, U18, U21 and 1st Team) and a significantly lower percentage of fat mass in the 1st team in comparison to the other tested teams (U21 and U18), $p < 0.05$. In study (Mala et al. 2014), authors observed two youth soccer teams from the Czech Republic (junior team, n = 50 and adolescent team, n = 33, U17) and found a significantly higher amount of fat mass ($p < 0.01$) in the adolescent players (14.64±2.43 %) compared to the junior players (12.15±2.83 %). Diversity in the inactive fat mass proportions results from the different energetic demands of the individual playing positions. Midfielders cover a greater area than defenders or attackers. According to Tumilty (1993), among the defensive players, the fullbacks usually cover more area than central backs because they are usually more involved during the attack phase (Arnason et al. 2004). Midfielders cover a greater area at lower intensity, while attackers perform more sprinting. Although the physiological and energetic demands of goalkeepers are different from the outfield players, the body fat proportion should not exceed 11.5 – 12 percent for any male soccer player, irrespective of their playing position (Gil et al. 2007).

While monitoring maladaptive changes based on playing practice, the researchers expected to find morphological asymmetry in the lower limbs of side position players (wide midfielder, goalkeepers, fullbacks) who had a higher preference for the dominant lower limb and also in goalkeepers (lower limb dominance). However, this hypothesis was not confirmed, with the greatest asymmetries detected in fullbacks, central midfielders and central defenders (Table 2). The results for goalkeepers can be explained by the fact that because one leg is preferred for kicking medium and long distances (preferred leg), the other leg is the take-off leg, which may compensate for the different activities between the two legs. In further research, it would be interesting to examine the bilateral strength asymmetries between knee extensors and flexors. Maly et al. (2016) reported a significantly higher prevalence of strength asymmetry in knee flexors compare to extensors ($\chi^2 = 4.11$, $p < 0.05$) in youth footballers A preference for the dominant leg was confirmed by Milsom et al. (2015), who showed a significantly higher proportion of lean body mass ($p < 0.05$) in the dominant leg and also in other segments (left arm, right arm, trunk, left leg, right leg) in a comparison between players of the English premier league 1st team and U18 players (n = 75).

CONCLUSION

Research has shown differences between anthropometric indicators and BC parameters in soccer players of different field positions. The team member's field position is of extreme importance in the interpretation of morphological data because there are specific physical demands for each specific player's position. A model of player with an optimal body morphology and BC for all field positions is impossible to unambiguous describe. Maladaptive effects in terms of different segmental muscle mass proportions between the preferred and non-preferred leg may represent a potential injury risk for a player, especially for fullbacks and wide midfielders. Therefore, any detected asymmetries should be systematically monitored and compensated by specific development exercises.

RECOMMENDATIONS

In terms of clinical practice, these results may be beneficial for fitness coaches, physiotherapists, nutrition specialists, doctors and other clinical staff involved with professional soccer. The researchers recommend tracking body composition parameters using bio-impedance measurements as a possible non-invasive method when monitoring quality of soccer's preparedness from point of view morphology. Further research should focus on BC changes during the seasonal periodization, hot environment conditions as well as influence of specific soccer fitness training (strength and conditioning).

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