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Training-induced changes in morphological and motor parameters in female football players

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Abstract

Aim of Study. The aim of this study was to analyse morphological and motor changes in young elite female football players during preparatory phase of a yearly training cycle. We assumed that preparatory phase in football training causes a decrease in body fat mass, increase in body weight, particularly in muscle mass of lower limbs, as well as an improvement in motor skills, endurance and speed. Methods. The study included elite female football players from KKP MAX-Sprint Bydgoszcz team. Their basic morphological parameters, including body composition and physical performance expressed by outcomes of flexibility, static and explosive strength, speed and endurance EUROFIT battery tests, were documented at two time points: beginning and end of preparatory phase of a yearly training cycle. Data. The Shapiro-Wilk test (assessment of the distribution of variables), Student t-test (assessment of the significance of the dependent variables' differences) and Mollison's index (assessment of the scope of changes of the variables tested) were used. The threshold of statistical significance for all tests was set at 0.05. Results. Morphological changes were manifested mainly by an increase body weight (D = 0.78 kg, p = 0.012) including protein content (D = 0.15 kg, p = 0.005) and in body fluid volume (D = 0.33, p = 0.032) and fat-free mass, particularly in lower limbs (for the right leg D = 0.12 l, p = 0.003; for the left leg D = 0.10 l, p = 0.006). Motor changes were manifested by an improved speed agility (D = 2.79 s, p = 0.000), flexibility (D = 6.25 cm, p = 0.000), explosive strength (D = 8.67 cm, p = 0.001) and static strength (D = 3.00 kG, p = 0.016). Conclusions. A significant increase in muscle mass and speed suggests that football training exerts specific, desirable effects on morphological and motor characteristics in female players. Preparatory phase in football training does not result in unfavourable changes in morphological and motor characteristics in female players.

KEYWORDS: competitive sports, body composition, physical fitness, preparatory phase, feminine sports.

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Introduction

Football, until recently traditionally considered a masculine discipline, is now played by a growing number of women who often hold vital roles in football operations such as referees, coaches and executives. This phenomenon is also observed in many other disciplines but research on a causative role of sexual identity did not confirm hypothesis of its influence when pursuing sports traditionally perceived as masculine domains [22, 23]. Therefore, it is possible that a choice particular discipline may be determined by socio-environmental factors and specific personality-related predispositions in female athletes [5, 20, 24, 27]. Sports training and recurring long-term selection process cause profound changes in biological structure of a player, attributed to various disciplines of sports [2, 6, 16, 21]. Therefore, female football players are likely to differ from women participating other team sports as well as from the population of young women overall in terms of their body structure and physical performance.

Both, football training and competition are associated with relatively high risk of injury, therefore appropriate preparation with particular attention to technique and condition becomes of vital importance [11, 30]. In the case of female teams, dimorphic differences should be considered in selecting exercises and training loads in order to achieve the expected level of performance and minimize risks of potential injuries, and to avoid unfavorable mental changes associated with an effect of female physicality on decisions of referees and spectators' perception [18, 25].

The preparatory phase is associated with a gradual increase in training loads, aimed at achieving and maintaining appropriate level of performance during the competition period. Such attitude may be reflected by multimodal changes in morphological and motor characteristics in both, male and female athletes [17, 26]. Thus, the aim of this study was to analyse morphological and motor changes in female elite football players during preparatory phase of their yearly training cycle; moreover, we compared basic morphological and motor characteristics of this group with these in women participating in other team sports. We assumed that preparatory phase in football training causes a decrease in body fat mass, increase in body weight, particularly in muscle mass of upper limbs, as well as an improvement in motor skills, endurance and speed attributed to this sport discipline. Due to the relatively high intensity of football training and its speed-endurance nature, we supposed that female football players differ with regards to their body structure and physical fitness levels from the general population of young healthy women and women participating in other team sports.

Methods

The study included 15 elite female football players from KKP MAX-Sprint Bydgoszcz team. Basic morphological parameters of the athletes, i.e. body height and weight were documented at the onset of preparatory phase and body composition was determined by the means of electric bioimpedance using the In Body 3.0 Body Composition Analyzer Biospace Co., Ltd device. The measurements of physical performance metrics such as flexibility, static and explosive strength, speed and endurance were recorded using EUROFIT battery test [1]. All tests were repeated shortly before the competition phase. Survey outcomes and analysis of training documentation were included in our study. Finally, we gathered extensive information about training plans and performance results of 12 athletes aged between 16 and 24 years. With the exception of one player who continued training after childbearing, most of the examined athletes were pupils or graduates at secondary or further education level; moreover, the group included a physical education graduate. The age of examined sportswomen reflected their training experience: shorter than two years in four athletes and longer than five years in another four individuals (Table 1). Football was the only sport they were involved in; its choice was attributed to personal interests and childhood experiences as well as information provided by physical education teachers.

Table 1. Statistical characteristics of age, training experience and body height in analysed football players

Parameter	n	min-max	Mean ± SD
Age (years)	12	16.0-24.0	18.67 ± 2.74
Training experience (years)	12	1.0-8.0	4.83 ± 2.25
Body height (cm)	12	150.0-171.0	165.60 ± 5.62

During the observed period, the athletes completed 114 hours of trainings in form of 90 to 120-minute training sessions delivered six days per week. The endurance training was scheduled three times per week and took place on a sport track or in the field. Two sessions delivered in a sports hall were aimed at developing agility and strength. Fitness training included weekly sessions. Each micro-cycle ended with a post-training restitution such as sauna or salt bath and massage.

Training sessions focused on improvement in endurance (52%, including 21% for aerobic and 79% for specialised endurance), speed and agility (20%), strength and jumping abilities (11%), technical and tactical skills (17%).

At the end of preparatory phase, observed female players participated in one-week training camp where they trained 2 or 3 times a day. The main aim of these sessions was to improve endurance (56%) and running speed (28%); the remaining time (16%) was spent on strength and technical exercises, frequently in a personalized form.

Mediocrity in distribution and significance of differences between mean values in observed parameters were determined with Shapiro-Wilk test and Student t-test for small dependent samples, respectively. The threshold of statistical significance for all tests was set at 0.05. The relative changes in analysed parameters were expressed as Mollison's index.

To allow an in-depth analysis of the researched group, we compared their baseline characteristics with respective parameters in women participating in speed skating,

volleyball or basketball, i.e. disciplines with dissimilar exercise profiles, as well as with results in female students of physical education, technical or medical disciplines, as requiring certain yet disparate levels of fitness [3, 4, 10, 15, 19, 28, 31, 32].

Results

The data on morphological parameters and body composition in observed female football players are summarized in Table 2. Apart from the mean body height, the values of all studied parameters increased throughout the study period, mostly within the statistical significance. The only differences that lacked statistical significance were those in fat mass and extracellular fluid volume in trunk and upper limbs. The most pronounced changes pertained in fluid content in lower limbs, as well as in protein content, total body weight and BMI. In turn, the least pronounced changes were documented in fluid content in trunk and upper limbs. Therefore, the increase (LBM) in fat-free mass

Table 2. Morphological characteristics in analysed football players

Parameter	Measurement no.	Mean ± SD	D	t	p	Mollison's index
Body weight (kg)	I	60.35 ± 5.10	0.78	2.98	0.012*	0.149
	II	61.13 ± 5.23				
BMI	I	22.05 ± 2.05	0.27	2.81	0.017*	0.142
	II	22.32 ± 1.97				
Intracellular fluid (l)	I	22.97 ± 1.75	0.21	2.72	0.019*	0.123
	II	23.18 ± 1.79				
Extracellular fluid (l)	I	10.28 ± 0.90	0.11	1.68	0.121	0.120
	II	10.39 ± 0.92				
Total fluid (l)	I	33.25 ± 2.55	0.33	2.46	0.032*	0.126
	II	33.58 ± 2.62				
Protein content (kg)	I	12.09 ± 0.94	0.15	3.45	0.005*	0.156
	II	12.24 ± 0.96				
Mineral mass (kg)	I	2.67 ± 0.16	0.02	2.40	0.036*	0.125
	II	2.69 ± 0.16				
Fat mass (kg)	I	12.34 ± 2.49	0.29	1.28	0.228	0.118
	II	12.63 ± 2.46				
Fluid content in the right upper limb (l)	I	1.77 ± 0.18	0.01	1.24	0.242	0.059
	II	1.78 ± 0.17				
Fluid content in the left upper limb (l)	I	1.74 ± 0.18	0.01	0.53	0.608	0.055
	II	1.75 ± 0.18				
Fluid content in the trunk (l)	I	15.22 ± 1.09	0.04	0.66	0.524	0.036
	II	15.26 ± 1.11				
Fluid content in the right lower limb (l)	I	5.44 ± 0.44	0.12	3.82	0.003*	0.250
	II	5.56 ± 0.48				
Fluid content in the left lower limb (l)	I	5.42 ± 0.47	0.10	3.42	0.006*	0.200
	II	5.52 ± 0.50				

* significantly different at $p < 0.05$

Table 3. Results of motor tests in analysed football players

Test/Factor	Test no.	Mean ± SD	D	t	p	Mollison's index
Sit and reach (SAR)/flexibility (cm)	I	17.75 ± 7.99	6.25	5.39	0.000*	1.00
	II	24.00 ± 6.24				
Standing broad jump (SBJ)/explosive strength (cm)	I	186.75 ± 10.94	8.67	4.38	0.001*	0.69
	II	195.42 ± 12.52				
Right handgrip (HGR)/static strength (kG)	I	39.08 ± 3.55	3.00	2.83	0.016*	0.63
	II	42.08 ± 4.80				
Left handgrip (HGR)/static strength (kG)	I	38.25 ± 5.38	1.58	1.48	0.167	0.31
	II	39.83 ± 5.17				
Shuttle run, 10 × 5 m (SHR)/running speed, agility (s)	I	19.5 ± 0.69	2.79	13.80	0.000*	4.88
	II	16.71 ± 0.57				
Endurance shuttle run (ESR)/ cardio-respiratory endurance (n)	I	8.17 ± 1.70	0.25	1.15	0.275	0.19
	II	8.42 ± 1.31				

* $p < 0.05$

Table 4. Comparison of morphological characteristics in analysed football players in comparison to characteristics of other female groups

Parameter	Analyzed group	Rowers 1	Medical College students 2	Physical education students 2	Volleyball players 3
Body height (cm)	165.6	167.3	166.1	168.1	182.7
Body weight (kg)	60.35	62.1	59.2	60.7	73.8
BMI	22.05	22.20	21.45	21.41	22.10
Fat-free mass, FFM (kg)	48.01	47.6	45.44	48.63	59.1
Intracellular fluid (l)	22.97	22.2	–	–	–
Extracellular fluid (l)	10.28	10.7	–	–	–
Total fluid (l)	33.25	32.9	31.46	33.69	43.3
Total fluid (%)	55	53	53	55	59
Protein content (kg)	12.9	12.0	11.46	12.26	–
Mineral mass (kg)	2.67	2.65	–	–	–
Fat mass (kg)	12.34	14.5	13.8	12.1	14.7
Adipose tissue (%)	20.3	22.9	23.3	19.9	19.9
Fluid content, right upper limb (l)	1.77	1.72	1.62	1.81	–
Fluid content, left upper limb (l)	1.74	1.71	1.59	1.78	–
Fluid content, trunk (l)	15.22	14.9	14.33	15.54	–
Fluid content, right lower limb (l)	5.44	5.35	5.19	5.49	–
Fluid content, left lower limb (l)	5.42	5.38	5.19	5.49	–

Table 5. Comparison of results in motor tests in analysed football players in comparison to results of other female groups

Test/Factor	Analyzed group	Speed skaters 4	Volleyball players 4	Basketball players 4	AMB students 5, 6	ATR students 7	AWF students 8
Sit and reach (SAR)/ flexibility (cm)	24.00	–	–	–	31.32	30.17	30.08
Standing broad jump (SBJ)/ explosive strength (cm)	195.42	151.38	156.25	143.25	180.76	177.18	188.27
Handgrip (HGR)/ static strength (kG)	42.08	16.08	20.75	17.63	34.13	27.09	37.59
Shuttle run, 10 × 5 m (SHR)/ running speed, agility (s)	16.71	22.11	22.48	21.45	21.09	21.37	19.45
Endurance shuttle run (ESR)/ cardio-respiratory endurance (n)	8.42	–	–	–	5.65	4.28	6.87

(FFM, 48.03 ± 3.63 – 48.5 ± 9.48 kg, D = 0.47; t = 3.0596*) was recorded mostly in lower limbs, whereas changes in muscle mass in upper limbs and trunk were not found.

A similar trend was noted in motor test results, summarized in Table 3. Apart from outcomes of 10 × × 5 m shuttle run where lower values correspond with better results, we observed an increase in results in all remaining tests. No statistically important changes were found only in left handgrip test and multistage endurance run. The most pronounced changes pertained to outcomes of agility and flexibility tests, and the least evident ones in results of endurance run. A small number of respondents require caution in interpreting the observed changes, especially in the area of endurance.

We compared morphological and motor characteristics in female football players at the onset of preparatory phase to these in other groups of young women. The data on morphological characteristics and body composition in female football players corresponds with that in female students from the Medical College; also the mean BMI was similar to that in female rowers and volleyball players.

The parameters in body composition in analysed players were similar to physical education students, established as a reference group of active women displaying high levels of fitness. Levels of fat-free mass (FFM) and body fat mass and percentage in both groups were found to be highly similar. However, apart from of fat tissue, all other body composition parameters in football players were significantly higher in comparison to physiotherapy students and significantly lower than in volleyball players (Table 4).

The results of motor tests presented in Table 5 revealed better outcomes of all performance tests in female football players in comparison to the reference group of other women.

Discussion

The research proves that participation in 9-week preparatory phase of a yearly training cycle resulted in an increase in mean body weight and therefore contributed to higher BMI in examined female athletes. Mean BMI in football players was similar to that in young female rowers, albeit slightly higher than in female students who did not participate in sports training on a regular basis. These findings, as well as data on body composition, suggest that targeted training induces changes in morphology in female athletes. Differences in body composition in physically active and inactive individuals were documented in a number of previous studies [7, 8, 9, 10, 12, 26]. Čabrić observed distinct hypertrophy of skeletal muscles in individuals who are engaged in speed sports in comparison to non-participants [7, 9]. High levels of physical activity are manifested by an increase in muscle strength and mass, and consequently in fat-free mass (FFM); the latter quite readily reacts to various exogenous factors and thus may be useful in detecting morphological changes [26]. Čabrić et al. and Grund et al. revealed that intensive sports training is associated with an increase in muscle mass, FFM and total fluid content [7, 10]. The increase in muscle mass and fat-free mass (FFM) in our participants pertained mostly in lower limbs. In contrast, intensive training associated with preparatory phase was not reflected by significant changes in muscle mass in trunk and upper limbs. Therefore, it could be assumed that this result reflects the degree of employment of muscular apparatus in football training, as previously stated in our hypothesis.

However, it is noteworthy that during the observation relatively limited time was spent on speed and strength exercises, both related directly to an increase in muscle mass and often leading to a decrease in body fat mass.

A minor increase in body fat mass may indicate low intensity and volume of strength training as well as

predominance of endurance and general exercises during preparatory phase. However, it should be noted that exercise-induced changes in adipose tissue content are relatively less pronounced in comparison to fluctuations in fat-free mass (FFM). This was confirmed in a study of young rowers, where a 0.8% decrease in body fat was noted during preparatory phase twice long as that in our football players [15]. Thus, we suggest that a 9-week-long preparatory phase in female football players from Bydgoszcz may be too short to exert significant changes in their adipose tissue content. Alternatively, it needs to be considered that the intensity of endurance training was too low to be reflected by significant changes in body fat. This assumption may be supported by the fact that documented changes in endurance level were relatively least pronounced of all analyzed motor characteristics. However, further studies on larger samples are needed to confirm these results.

Overall, the mean parameters in body composition in our participants did not differ markedly from those in physical education students. However, except from body fat mass, all other parameters in our football players were significantly higher in comparison to those in Medical College students, considered a reference group of young healthy females [13, 14, 31, 32].

Also, it should be emphasised that despite similar body height and weight, football players were characterised by relatively greater muscularity in lower limbs than young women from the general population.

Based on the observation of changes in morphological parameters that quite readily react to various quite exogenous factors, we expected a significant impact on motor characteristics in athletes caused by training sessions [17]. This observation is consistent with the initial hypothesis as fully supported by our study findings, except from training-related changes in endurance levels. Therefore, it may be concluded that preparatory phase in football training have positive effect on harmonious development of most motor components in physical fitness in female football players. However, it should be stressed that we observed positive changes either in motor components of physical fitness or in its health-promoting components. We believe that lack of significant changes in levels of endurance, regarded as an essential element of both abovementioned component groups, deserves more comprehensive analysis especially that our athletes spent more than the half of their training time during the observed period developing this skill. Therefore, it can be assumed that relatively less pronounced improvement in endurance in football players might be caused by its higher prior level. The test used in our study is considered mainly a measure of aerobic endurance which provides the basis for football-specific manifestations of mixed endurance, 40% of the overall training time during preparatory phase, and as much as 80% of the total endurance training time was devoted to its development. In the case of football players, endurance is frequently associated with strength and speed, and our participants displayed most pronounced changes in these motor skills. This observation makes our hypothesis valid regarding the more developed of motor features directly related to sports disciplines conducted by female athletes.

The limited number of players from one football club is a limitation in the analysis of the results of the presented research. Thus, the following conclusions cannot be applied to the general population of women practicing football.

Conclusions

1. An increase in most of body components and improvement in motor skills in athletes observed during preparatory phase of a yearly cycle reveal a positive effect of football training on female organism.
2. The greatest gains in muscle mass and speed suggest that soccer training exerts specific, desirable effect on morphological and motor characteristics in female players.
3. The spectrum of morphological and functional changes in analysed athletes and fact that the latter did not differ from reference group, with exception of lower body fat mass and higher levels of motor skills, what might presumably be characteristic features of examined female football players profile, suggest a separate reflect a distinct biological structure of elite female football players.

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