Original Article

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Seasonal variation of speed, agility and power performance in elite female soccer players: effect of functional fitness

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Abstract

The purpose of this study was to evaluate the changes of speed, agility and power performance during one soccer season and the impact of functional fitness on changes in motor performance in elite female soccer players. This study was conducted with 18 members of the Polish Women's National Football Team. The analyzed training season was divided into four training phases. Physical performance was assessed by a test of quickness - the 5m sprint, tests of maximal speed - the 30 m sprint, test of agility - L-run test and tests of lower limb explosive power - counter movement jump (CMJ) and counter movement jump with arm swing. Functional fitness was assessed using the Functional Movement Screen (FMS). Individual functional training as well as a training plan based on FIFA 11+ prevention were utilized. The analysis showed significant improvement in the CMJ test ($F=3.02$, $p<0.05$) and FMS score ($F=5.959$, $p<0.01$) during the in-season. Other parameters of physical performance were stable during the evaluation period. Positive correlations between baseline FMS score and changes of athletes' 30m sprint performance ($r=-0.48$, $p<0.05$), *total in-season change* of FMS score and total *in-season* change of 5m sprint performance ($r=-0.53$, $p<0.05$) were observed. Female soccer players during the in-season demonstrated a relatively good level of physical performance which corresponds to their particular training phase. Functional fitness intervention appears to be an effective way of improving speed, acceleration, and power performance in elite female soccer players.

Keywords: functional performance assessment, physical performance examination, Women's soccer

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INTRODUCTION

Soccer is a high-intensity intermittent sport that requires technical skill, tactical awareness and an extremely high level of physical fitness. It also involves multi-faceted and continuous changes of running direction and intensity, accelerations, and a variety of dynamic actions (forward and backward running, lateral actions, jumping, tackles) [1-4]. It has been reported that elite female players run about 10 km at 80-90% of their maximum heart rate (close to the anaerobic threshold) during a 90-minute match [5,6]. This data shows the importance of aerobic capacity in a soccer match. It was found that mean VO2 max values of female soccer players were between 45.1-55.5 ml/kg/min with the variation of players' competition levels and their playing positions [2,7]. Elite female soccer players performed approximately 1379-1459 different activities every 4 seconds at 9-11 km during a game, and about 125-154 of these activities were high intensity runs with a mean duration of 2-3 seconds [5,8]. Therefore, power, strength, speed and agility capacity are the most important factors in performing short-term and explosive actions [9-11].

The soccer season is characterized by long competition and short preparation period [12]. Physiological stress is maintained for long periods throughout the season. Michailidis [13] reported that cortisol hormone increased by 23% in the middle of the season. Moreover, Silva et al. [14] found significant changes in biomarkers of physiologic stress (muscle damage and oxidative stress-related markers) in female players during the season. Under these circumstances, the sustained or enhanced physical performance of the soccer players were based on proper exercise stimuli, which allows the body systems to recover from and adapt to multiple stressors. Therefore, regular monitoring of training data and physical fitness of players throughout the season is very important for structural improvement, progression of performance, and injury prevention [12]. In addition, monitoring physical fitness parameters throughout the season is important in order to identify players' strengths and weaknesses in their motor functioning. The current literature associated with seasonal changes in the physical performance of soccer players reveals some inconsistent evidence [15-17]. Although there are some studies examining seasonal changes in physical performance of elite young female soccer players [17,19,20], seasonal variations of physical performance in young players can be influenced by growth and maturation. Studies examining changes in physical capacities of adult elite female soccer players during one soccer season are limited, so the first aim of this study was to determine seasonal changes in physical performance, i.e. lower limb power, sprint performance (5m, 30m), and agility of elite adult female soccer players. We hypothesized that the level of physical performance during the in-season in elite female soccer players is relative stable and corresponds to their particular training phase.

A number of recent studies have identified the importance of athletes' functional fitness in relation to improving their physical performance; in particular levels of strength, power, and speed [21-23]. However, not all experimental studies support these observations. For example, Tse et al. [24] reported a lack of improvement in various motor performance measures in rowers (vertical jump, broad jump, shuttle run, 40-m sprint, overhead medicine ball throw, 2000 m maximal rowing ergometer test) after 8 weeks of functional fitness intervention. In contrast, Nesser et al. [25] observed a significant effect of football players' total core muscle strength on 20 and 40 yard sprint times, 10 yard shuttle run time, squats and countermovement vertical jump. Furthermore, Niewolna and Zwierko [26] analyzed the effects of a two year program of core stability and functional exercises on strength and speed in young female soccer players. This intervention resulted in positive changes in the strength of several muscle groups and reduction in 30m sprint time. Taking into account that functional fitness can influence motor performance, the second aim of this study was to analyze the relationship between a functional movement screen test and changes in in-season motor performance in elite female soccer players. We accepted the assumption that the level of functional fitness determines the positive in-season changes in players' physical performance.

MATERIAL AND METHODS

Participants

This study was conducted with 18 elite female soccer players. All participants were members of the Polish Women's National Football Team. The mean age of this group was 26.42±3.68 years and mean sport experience was 15.25±3.08 years. Goalkeepers were excluded from this study. The mean value of body mass during initial measurement was 62.73±6.84 kg. *The mean value of body height was 169*±4.08 cm.

The training season analyzed in this study was divided into four training phases. Testing sessions occurred at the transition of each training phase:

1. At the start of game season, after pre-season training (T1) (September)
2. At the midpoint of the first round of soccer season (T2) (November)
3. At the start of the second round of soccer season (T3) (February)
4. At the midpoint of the second round of soccer season (T4) (April)

After each national team camp, players received individual functional training plans based on their FMS test results. Their exercise were selected from the database presented at the official website of the (Functional Movement Systems, www.functionalmovement.com) and were individually selected for each player by a physical preparation trainer. Exercises for the participants were based on their individual set of FMS scores. The main groups of exercises in the study group were those aimed at improving knee stabilization and strengthening the group of sciatica-tibial muscles. Individual functional training was carried out daily after regular training or during free time. Apart from this, all players received the same prehab training plan based on the FIFA 11+ prevention program. The FIFA 11+ is a 20 min warm-up program with neuromuscular training consisting of 15 exercises developed to prevent lower extremity injuries in soccer players [27].

Methods

Lower limb explosive power

Lower limb explosive power of athletes was determined using an optical measurement system (Optojump Next, Microgate, Bolzano, Italy) during a counter movement jump test with hands on hips (CMJ) and a counter movement jump with arm-swing (CMJA). During the CMJ, the participant maintained his trunk in an upright posture with his hands on his hips. The test was performed with both feet. For the CMJA, the participant was allowed to swing their arms backward (during the downward movement), and then forward and upwards (during the push-off phase). The CMJA was performed first with both feet and then with one leg (dominant and non-dominant). Players performed the two measured attempts. To familiarize players to the testing, two trials were completed followed by two measured attempts. The best of the results was used for further analysis.

Sprint Testing

Running speed was measured using an optical measurement system (Microgate Witty, Bolzano, Italy). Participants were to perform a 30 m sprint twice. Time was measured at 5 m and 30 m distance. The best of these results was used for further analysis. To familiarize players to the testing, two trials were performed followed by two measured attempts.

Agility

Agility was also measured using an optical measurement system (Microgate Witty, Bolzano, Italy). The "L-run" test was used for this purpose. The test was performed on the pitch with artificial grass. Photocells were situated at 4 points: 1 – starting point, 2 – 90-degree turning point situated 5 m from the start, 3 and 4 – at the finish line on the right and left side, 5 m from the 90-degree turning point. Participants performed one "upside-down L-shape" run to the left and one "upside-down L-shape" run to the right. The participant was allowed one (but only one) repetition in case the participant slipped during the turning. To familiarize players to the testing, two trials were performed followed by two measured attempts. The best of the results was used for further analysis.

Functional fitness

Functional fitness was assessed using the Functional Movement Screen (FMS) (Cook et al. 2014). The FMS consists of seven basic movement patterns to identify imbalances in mobility and stability during *functional movements.* The total FMS score is the summation of all 7 scores, resulting in a maximum of 21 points. A score of "3" denotes correct performance of the movement pattern, "2" indicates that the subject needs compensatory movements to complete the exercise, and a score of "1" is given when the individual is unable to perform the movement pattern at all. In cases where subjects feel pain while performing an item, a score of "0" is given.

Statistical methods

Data were expressed as mean and standard deviation. The normality assumption was confirmed using the Shapiro-Wilk test. A one-way ANOVA measure for the repetition test factor was conducted. Partial eta-squared (ηp^2) values were reported to determine effect size. Bonferroni post-hoc analyses were conducted to examine pairwise comparisons. Pearson's correlation was used to determine the relationship between functional fitness and in-season changes of physical performance tests. A p-value of less than 0.05 was considered significant.

RESULTS

Power performance

Four power measurements taken during the in-season of female soccer players were analyzed (Tab. 1). The analysis showed statistically significant changes of CMJ parameters ($F_{(3.68)} = 3.02$, $p=0.036$, $\eta p^2=0.118$). A Bonferroni post-hoc test indicated a significant differential effect between T2 and T1 in CMJ results (34.450±2.513 vs. 31.944±3.009, p=0.041, Fig.1). The total increase during in-season CMJ test results (T4) was 5.478% according to the initial state (T1). A similar direction of change was observed for the CMJA test. The average increase of CMJA test results was 5.013% during the in-season. However, the variation of CMJA test results was insignificant ($F_{(3.68)} =2.01$, $p=0.120$, $\eta p^2 =0.082$).

Sprint and agility performance

There were no significant differences in 5m run test results in the four measurements taken ($F_{(3.68)} = 0.40$, $p =0.750$, $\eta p^2 =0.017$). Similarly, the results of the 30 m run test ($F_{(3.68)} = 1.58$, $p =0.201$, $\eta p^2 =0.065$) and results of the L-run test ($F_{(3.68)} = 1.83$, $p =0.149$, $\eta p^2 =0.074$) did not differ significantly during the season. The total reduction of average running times during the season (T4 vs. T1) was 2.249 % for the 5 m run test, 2.756 % for the 30 m run test, and 2.120 % for the L-run test. The results of sprint and agility performance measurements are presented in Table 2.

Functional fitness

There was a significant differential intragroup effect in the FMS test results during the season ($F_{(3.68)}= 5.959$, $p=0.0001$, $\eta p^2=0.207$). A Bonferroni post-hoc analysis showed significant differences between T3 and T1 (17.889 vs. 16.445, p=0.041), T4 and T1 (18.389 vs. 16.445, p=0.002) and T4 and T2 (18.389 vs. 17.00, p=0.031) measurements (Figure 2). The total increase of average results in the FMS test during the season (T4 vs. T1) was +12.117%.

Relationships between functional fitness and physical performance

Pearson's analysis showed significant positive correlation between initial levels of the functional movement screen test (FMS_{T1}) and in-season changes of athletes' CMJ power performance in all measurements ($CMJ_{\Delta T2\text{-}T1}$: r= 0.56, p<0.05; $CMJ_{\Delta T3\text{-}T1}$: r= 0.50, p<0.05; $CMJ_{\Delta T4\text{-}T1}$: r= 0.57, p<0.05;). There was a positive correlation between FMS_{T1} and changes of athletes' 30 m sprint performance ($30m_{\Delta T2\text{-}T1}$: r= -0.48, p<0.05; $30m_{\Delta T3\text{-}T1}$: r= -0.47, p<0.05). Moreover, there was a significant positive correlation between *total in-season change* of functional movement screen test ($FMS_{\Delta T4\text{-}T1}$) and total *in-season* change of 5 m sprint performance ($5m_{\Delta T4\text{-}T1}$: r= -0.53, p<0.05). *Pearson's correlation* coefficients are presented in Table 3.

Table 1. CMJ and CMJA power performance during the season in female soccer players

Test times	CMJ mean±SD	Δ[%]	F	CMJA mean±SD	Δ[%]	F
T1	31.944±3.009	-	3.02*	37.117±3.281	-	2.01
T2	34.450±2.513	+8.253		39.633±3.198	+6.928	
T3	32.550±2.534	+2.237		38.439±3.402	+3.810	
T4	33.567±2.725	+5.478		38.889±2.722	+5.013	

*p<0.05; Δ – average change in subsequent test runs in relation to T1; CMJ - counter movement jump; CMJA - counter movement jump with arm-swing

Table 2. 5 m and 30 m sprint performance and L-run agility performance during the season in female soccer players

Test times	5m mean±SD	Δ[%]	F	30m mean±SD	Δ[%]	F	L-run mean±SD	Δ[%]	F
T1	1.150±0.096	-	0.40	4.617±0.159	-	1.57	5.727±0.165	-	1.83
T2	1.131±0.071	-1.151		4.555±0.183	-1.329		5.651±0.184	-1.330	
T3	1.128±0.086	-1.532		4.547±0.194	-1.515		5.662±0.139	-1.104	
T4	1.121±0.079	-2.249		4.489±0.169	-2.756		5.604±0.141	-2.120	

Δ – average change in subsequent test runs in relation to T1

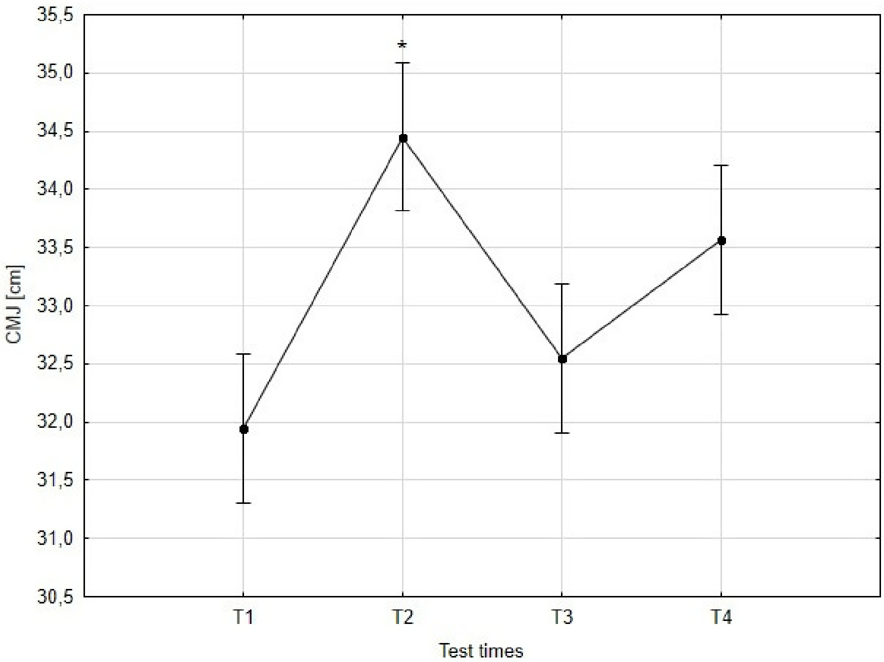

Figure 1. Counter movement jump test results during the in-season are presented as means and **±**SEM. A significant intragroup differences (p=0.036) between tests T2 vs. T1 in female soccer players is denoted with (*).

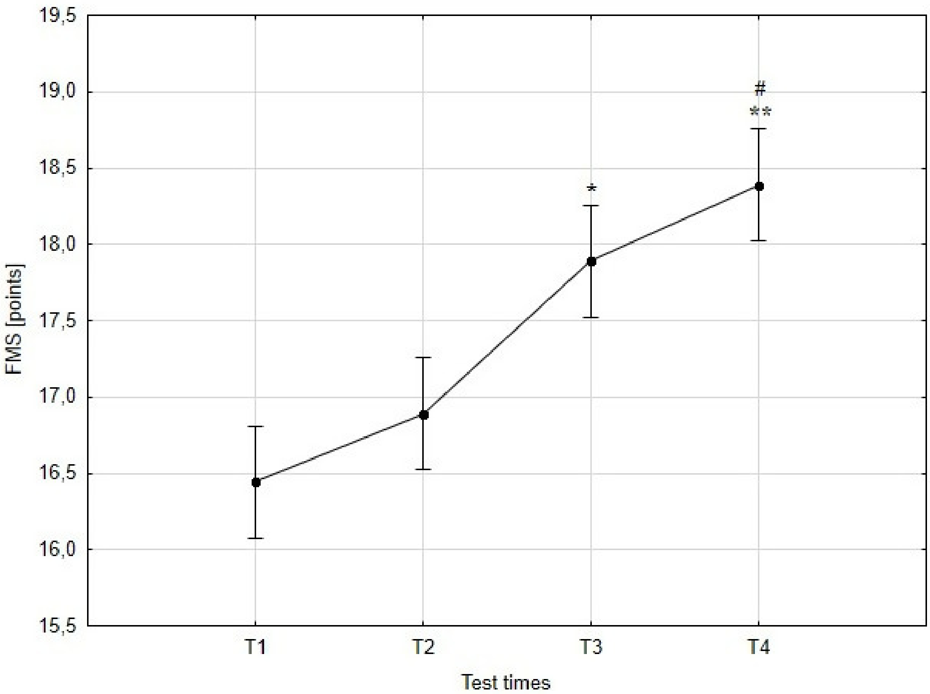

Figure 2. Functional movement screen test results during the in-season are presented as means and ±SEM. A significant intragroup differences between tests T3 vs. T1 (p=0.041) is denoted with (*),T4 vs. T1 (p=0.002) is denoted with (**),and T4 vs.T2 is denoted with (#).

Table 3. Pearson's correlation coefficient*s* between (1) initial levels of the functional movement screen test (FMS_{T1}) and in-season changes of athletes' physical performance (2) total in-season change of the functional movement screen test ($FMS_{\Delta T4-T1}$) and total in-season changes of athletes' physical performance (Δ_{T4-T1}). Statistically significant coefficients (p<0.05) are bold.

FMS	*Δ* CMJ			*Δ* CMJA			*Δ* 5m			*Δ* 30m			*Δ* L-run		
	T2-T1	T3-T1	T4-T1	T2-T1	T3-T1	T4-T1	T2-T1	T3-T1	T4-T1	T2-T1	T3-T1	T4-T1	T2-T1	T3-T1	T4-T1
FMS_{T1}	**0.56**	**0.50**	**0.57**	0.16	0.07	0.07	0.45	0.27	0.31	**-0.48**	**-0.47**	-0.46	-0.38	-0.06	-0.24
FMS Δ_{T4-T1}	-	-	0.03	-	-	0.13	-	-	**-0.53**	-	-	0.14	-	-	0.39

DISCUSSION

The aim of this study was to determine seasonal changes in physical performance i.e. lower limb power, sprint performances (5 m and 30 m) and agility of elite adult female soccer players and determine the relationships between physical performance and functional movement screen scores. We hypothesized that the level of physical performance during the in-season in elite female soccer players is relatively stable and corresponds to their particular training phase. In the present study, statistically significant improvements (p<0.05) in CMJ test results and FMS scores (p<0.05) during the in-season were found. In contrast, there were no significant differences (p>0.05) found between the 5 m run test, 30 m run test and the L-run test during the season.

An interesting finding of this study was the lack of any significant decrement of analyzed parameters during the in-season. Although most test results were relatively stable or showed an improvement, it has been observed that the players at the end of the preparatory period (T1 and T3) did not reach their maximum performance, with the exception of running at 30 m. The explosive power demonstrated by the CMJ and CMJA test results were improved during the season but peak power performance was observed at the midpoint of the first round of soccer season (T2). Castagna and Castellini [28] indicated thresholds of acceptable vertical jump values for Italian elite female soccer. The authors have suggested scores over 34.4 cm and 32.9 cm for the CMJ. The results of the present study confirmed suggested norms for elite female soccer players. In accordance with the CMJA results, a significant relationship has been observed between training status and baseline jump performance, as young players demonstrated lower baseline CMJA performance than collegiate soccer players [29,30]. In our study, no significant variation ($p>0.05$) in CMJA results was noted.

The total reduction of average running for the 5 m run test in our study was 2.249% during the season. Compared to our results, Taylor et al. [16] reported that 5 m acceleration performance of elite youth female soccer players decreased at the mid-season (8.0 and 3.6%). In term of sprint performance, Mara et al. [18] found that 25 m run results peaked at the mid-season, demonstrated by a 3.1% increase in comparison to pre-season, but declined towards the end of the season. This study did not support our results. We observed systematic reduction of speed times in the subsequent periods but the changes were not significant ($p>0.05$) (Table 2). A similar effect was observed in agility performance. It has been reported that the most effective types of exercise involve jump training [31], resisted sprint training [32] and assisted training related to neurological adaptations [33] were used to improve the speed and acceleration characteristics. Additionally, it was noted that neuromuscular factors combined with supramaximal training without peak power enhancement resulted in improvements in short distance speed performance of female players. The limitation of our study was the lack of analyzation of the training methods and load during the entire season, with the exception of the functional intervention.

Our findings confirmed previous study results that showed systematic core stability and functional exercises have positive effects on motor performance [21,22,25,34]. The mean of FMS test results during the season increased 12.117 %. Previous experimental results in youth female soccer players indicated that players with higher adherence to 'FIFA 11+' showed significant improvements in functional balance and reduced injury risk [27]. Furthermore, in male football players the 'FIFA 11+' program has shown positive physiological warm-up effects, enhancement of neuromuscular control, (core/lower extremity) and improvements in knee flexor strength similar compared to the standard warm-up procedure [35-37].

It is generally known that in daily soccer practice, functional fitness plays an important role in return-to-play strategy as a tool to achieve functional mobility and postural stability, and helping to manage the pre-preparation of functional soccer movements as a return-to-play screening tool [34]. The FMS includes lower body-focused tests (deep squat, hurdle step, in-line lunge) that seem to have minimal capabilities for identifying movement shortcomings that affect multi-directional sprinting and jumping, which are important features for team sports [36]. Kiesel et al. [39] examined the effectiveness of an off-season training program on FMS scores in expert players. An improvement in FMS scores above the injury threshold (≤14) was shown when compared to baseline state. Moreover, this study also showed positive significant changes in asymmetry following the intervention.

There is some evidence that strongly suggests the importance of FMS scores in soccer [40,41] but there are limited studies examine the relationship between FMS score and physical performance in adult female soccer players. Our second hypothesis that high level of functional fitness determines the positive in-season changes in players' physical performance was confirmed primarily by the power and sprint performance. According to the FMS results of this study, the baseline results of FMS were significantly correlated with season changes of athletes' CMJ power performance in all measurements ($p<0.05$). The positive relationship between FMST1 and changes of athletes' 30 m sprint performance ($p<0.05$) was observed. Moreover, a positive correlation was found between total in-season change of the FMS test ($FMS_{\Delta T4\text{-}T1}$) and total in-season change of 5 m sprint performance ($p<0.05$). A previous study conducted by Niewolna and Zwierko [26] also noted that systematic core stability exercises and functional training in female soccer players had a positive effect on 30 m sprint time and on maximal strength in 4 muscle groups; quadriceps femoris, abdominal obliques, shoulder girdle and chest. Moreover, Sedano Campo et al. [42] denoted that regular soccer training and plyometric training implemented for the lower extremities of female soccer players enhanced lower extremity explosive power and kicking speed of both lower extremities. Comfort et al. [43] specified that the improvement of back squat muscles positively affected sprint and jumping performance. Additionally, there was a high level of correlation between strength of leg muscles or lower body, and power production, speed at distances of 5 m and less [44], sprint and jumping performance [43,45]. It appears that the significant relationship between the FMS test results and motor performance is the result of enhanced neuromuscular control during functional interventions. It also appears to be important in relation to injury prevention [27]. This is an important aspect of optimizing psychophysical functioning and higher quality of life [46-47].

CONCLUSIONS

Female soccer players during the in-season demonstrated a relatively high level of physical performance with variability between each training phase. The results of this study can be considered important in terms of planning in-season training and consequentially improving game efficiency.

The study results identify the benefits of a structured exercise program and indicate how a functional fitness intervention could be implemented in elite female soccer players. To conclude, a functional fitness program appears to be an effective way of improving speed, acceleration, and power performance in elite female soccer players. Therefore, it would be beneficial for coaches to incorporate this intervention into their strength and speed programs.

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