Original Article

Age-related differences in linear sprint and power characteristics in youth elite soccer players

TOMÁŠ MALÝ¹, FRANTIŠEK ZAHÁLKA¹, PAVEL HRÁSKÝ¹, LUCIA MALA¹, JANA IŽOVSKÁ¹
DAVID BUJNOVSKÝ¹, MICHAL DRAGIJSKÝ¹, JOZEF MIHAL¹

¹ Faculty of Physical Education and Sport, Charles University in Prague, CZECH REPUBLIC

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Abstract:

Speed and power are important components of fitness performance and determine the level of success in soccer. High intensity activity during the game are important elements in soccer because increasing speed over a short distance may be necessary in crucial phases of the game, not only in adult, but also in young soccer players. The aim of this study was to identify speed and power variables and to determine their relationship among three different age categories, U16, U17 and U19. Speed variables were assessed using the following tests: a) linear speed: 5 m sprint (S5), 10 m sprint (S10) and 20 m flying sprint (F20); b) power vertical jump tests: Counter Movement Jump with Free Arms (CMJFA), Counter Movement Jump with Fixed Arms (CMJ). Multivariate analysis of variance showed a significant effect of age category on field physical performance in soccer players ($\lambda=0.471$, $F_{10,110} = 5.03$; $p < .01$, $\eta_p^2 = .31$). The test of between groups effect (regarding the age) revealed significant differences in S5, S10 and F20 running speed test; conversely, we found an insignificant effect in jump power tests (CMJFA, CMJ). A high rate of common determination was found between 5 m and 10 m sprints ($R^2 = 0.63 - 0.79$) and jump tests ($R^2 = 0.46 - 0.79$). A lower rate of common variance ($R^2 = 0.21 - 0.41$) was detected between linear 5 m sprint and maximum running speed in 20 m flying sprint (F20). Results of our study indicate that despite common physiological speed and power predispositions there are significant age-related differences in running speed and insignificant differences in the vertical jump assessment. These specificities should become an object of further research in young elite soccer players.

Key words: testing, performance, vertical jump, elite athletes

Introduction

Many contributing factors are relevant in determining the success of a soccer performance, especially that at the top level. Each player has different physical abilities, technical skills, tactical thinking and psychological characteristics and therefore he has his own role in the team. In terms of physical activity, there are different requirements on physical, physiological and bioenergetic expenditure. The soccer match is characterized by intermittent physical load in which periods of high intensity are alternated with periods of low intensity. Speed and explosive power are considered to be prerequisites for the success of youth soccer players (Reilly, Bangsbo, & Franks, 2000). High load intensity is a crucial element distinguishing players of elite and lower levels. Elite level players perform 2 – 3 km in higher running intensity (> 15 km/h) and 0.6 km in sprint (> 20 km/h) (Iaia, Rampinini, & Bangsbo, 2009). Elite players perform approximately 30 – 40 sprints of various lengths during a match and more than 700 turns (Bloomfield, Polman, & O'Donoghue, 2007). Stolen, Chamari, Castagna, and Wisloff (2005) reported that high-intensity activities occur approximately every 90 seconds during a match and last for 2 – 4 seconds. High intensity activity during the game is an important element in soccer because increasing speed over a short distance may be necessary not only for adults but also for youth soccer players in crucial phases of the game. For professional players, Andrzejewski, Chmura, Pluta, Strzelczyk, and Kasprzak (2013) reported that 90% of sprints were performed within 5 seconds. Some authors consider the player's first steps and the ability to gradually increase their speed as the most important component of the running performance during the game (Dellal et al., 2011; Sleivert & Taingahue, 2004). In terms of these findings, the 5 and 10 m tests appear to be suitable for the assessment of acceleration (Maly, Zahalka, Mala, & Teplan, 2014; Stolen et al., 2005; Strudwick, Reilly, & Doran, 2002; Teplan, Maly, Zahalka, & Mala, 2013). Faude, Koch, and Meyer (2012) stated that straight sprints are the most dominant actions when scoring goals in professional soccer. Most sprints were conducted without the ball. Thus, straight sprinting should be considered in fitness testing and training. However, players rarely reach their maximum speed during a match; therefore, the acceleration phase is crucial in game performance (Jovanovic, Sporis, Omrcen, & Fiorentini, 2011). Examining strength and power might be useful in monitoring professional soccer players' performance. Vertical jumping performance is a simple indicator of muscular strength of lower extremities and it is often used in assessment of changes caused by specific training (Kotzamanidis, Chatzopoulos, Michailidis, Papaiakevou, & Patikas, 2005;

Siegler, Gaskill, & Ruby, 2003; Zahalka, Maly, Mala, Teplan, & Hrasky, 2013). When assessing jumping performance, the most commonly measured parameters include the jump height achieved, maximum force produced at the take-off, rate of force development and also a shape of force-time curve during the jump is described. Gauffin, Ekstrand, Arnesson, and Tropp (1989) reported in their study that players from first two teams in the French highest league achieved better results in vertical jumps compared with teams at lower positions in the league table while Wisloff, Helgerud, and Hoff (1998) in a similar study in Norwegian elite soccer league found no significant differences between the first and last classified team. A vertical jump is one of decisive factors in soccer players. It is a complex action that depends on coordination (Bobbett & Schenau, 1988; Zahalka, Maly, Mala, & Teplan, 2012), type of muscle fibre and its stiffness (Bobbett, 2001) and maximum strength (Baker, 1996). Wisloff, Castagna, Helgerud, Jones, and Hoff (2004) reported that there is significant correlation between the vertical jump height and speed abilities in 30 m sprint; however, Chamari et al. (2004) did not confirm any significant relationship between sprint and height of a vertical jump. Other studies showed that players at higher performance level achieved significantly better results in acceleration and running speed compared with players at a lower level (Haugen, Tonnessen, & Seiler, 2013), significant correlation between maximum strength and running speed (Wisloff et al., 2004), and between acceleration speed and maximum running speed (Maly et al., 2014).

The aim of the study was to determine a level, differences and mutual determination of acceleration speed, maximum running speed and lower limb power in elite youth soccer categories.

Material & methods

Participants

The screened sample consisted of elite youth soccer players of U16, U17 and U19 categories, who compete in top competitions in their categories. Each team had five training units and one match during a common one-week micro-cycle. The U16 group was composed of 26 players (age = 15.3 ± 0.4 years, body height = 176.5 ± 6.2 cm, body mass = 73.8 ± 3.6 kg), U17 group consisted of 17 players (age = 16.4 ± 0.3 years, body height = 178.6 ± 5.8 cm, body mass = 75.9 ± 3.9 kg) and U19 group consisted of 19 players (age = 18.5 ± 0.3 years, body height = 179.7 ± 7.1 cm, body mass = 78.7 ± 5.6 kg).

Methods of data collecting and processing

Field testing was performed in outdoor conditions on artificial grass and the average temperature ranged between $17 - 19$ °C and humidity between $62 - 70$ %. The test was carried out in the first third of the season. Prior to the testing, the players performed a warm-up (15 min) which was composed of running, stretching and 5 sprints over a distance of 10 m. The period between the warm-up and the test was 45 min long and players performed activities focused on running speed. Speed indicators were assessed using field motor tests of running speed. Performance in sprints for 5 m (S5), 10 m (S10) and a flying sprint for 20 m (F20) after a 30 m run-up were measured using photocells (Brower Timing System, Utah, USA). In the sprint speed test, the players ran a 10 m distance; however, the 5 m performance was also measured. This test (S10) was selected to identify the linear speed of the players (Cometti, Maffiuletti, Pousson, Chatard, & Maffulli, 2001; Little & Williams, 2005). To assess maximal speed, we used a flying 20 m sprint after a 30 m run-up, which was also used previously with senior professional players (Little and Williams, 2005). The reliability of the maximum speed test with senior soccer players was ICC = 0.93 (Mirkov, Nedeljkovic, Kukolj, Ugarkovic, & Jaric, 2008). Vertical jumps (Counter Movement Jump with Free Arms – CMJFA and Counter Movement Jump - CMJ) were assessed by optic timing system Optojump (Microgate, Italy), which consists of two bars: first transmitting bar, second receiving bar. The light emitting diodes are located 3 mm above the surface. The bars were placed on the opposite sides of the artificial grass. The power tests were performed after sprints test. Duration between sprint and power assessment was 10 minutes. The research was approved by the Ethical Committee of the Faculty of Physical Education and Sports at Charles University in Prague. Measurements were carried out in accordance with the ethical standards of Declaration of Helsinki and ethical standards in sport and exercise science research (Harriss & Atkinson, 2011).

Statistical analysis

The results were expressed in absolute values and the evaluation was made with the use of basic statistical characteristics (Arithmetic Mean, Standard Deviation, Minimal and Maximal value). To investigate the main effect of the differences between the field soccer performances among the age categories we used Multilevel Analysis of Variance (MANOVA). To discover significant differences between the observed age groups, Analysis of Variance was used (ANOVA). In cases of significance between groups, we used Bonferroni's posthoc test. When the criterion of sphericity, as one of the conditions of ANOVA, which was assessed using the Mauchly's test (χ^2), was not met, degrees of freedom were adjusted by means of Greenhouse-Geisser's (GG) sphericity correction and then the statistical significance was assessed according to particular degrees of freedom. The probability of type I error (alpha) was set at 0.05. The probability of type II error (beta) was controlled using *posthoc* (retrospective) analysis and it was set at 0.2 (conventional value). Effect size was

assessed using the „Partial Eta Square” coefficient (η_p^2), which explains the proportion of variance of the monitored factor. Correlation analyses were performed to examine the relationship between selected variables. The coefficient of determination (R^2) was used to determine the interrelationships between variables. Statistical analysis was performed using IBM® SPSS® v21 (Statistical Package for Social Science, Inc., Chicago, IL, 2012).

Results

Multivariate analysis of variance showed a significant effect of age category on field physical performance in soccer players ($\lambda=0.471$, $F_{10,110} = 5.03$; $p < .01$, $\eta_p^2 = .31$). The test of between groups effect (regarding the age) revealed significant differences in S5, S10 and F20 running speed test (Table 1); conversely, we found the insignificant effect in jump power tests (CMJFA, CMJ).

Posthoc analysis revealed better performance in S5 test of older soccer players (U19) compared with both younger categories ($p < .01$). On the contrary, there were no significant changes between U19 and U17 in S10 test. However, in F20 test, we revealed a significant difference between players of U16 and U19. Common physiological basis of speed predispositions was confirmed between sprint at 5 and 10 m when the coefficient of determination was $R^2 = 0.63 - 0.79$ (Figure 1) and in jump tests $R^2 = 0.46 - 0.79$ (Figure 2). A lower rate of common variance ($R^2 = 0.21 - 0.41$) was detected between linear 5 m sprint and maximum running speed in 20 m flying sprint (F20) (Figure 3).

Table 1. The comparison of parameters indicating linear running speed and power assessment between monitored samples

Parameters		Descriptive statistic				ANOVA		Bonferroni's <i>posthoc</i> test
		Mean	SD	Min	Max	F	p	
Sprint 5 m (s)	U16	1.16	0.05	1.07	1.34	10.62	<0.01	U16 vs U17 ($p>.05$)
	U17	1.15	0.03	1.04	1.19			U16 vs U19 ($p<.01$)
	U19	1.09	0.06	0.91	1.16			U17 vs U19 ($p<.01$)
Sprint 10 m (s)	U16	1.91	0.06	1.81	2.11	9.09	<0.01	U16 vs U17 ($p<.05$)
	U17	1.85	0.06	1.72	1.95			U16 vs U19 ($p<.01$)
	U19	1.84	0.07	1.62	1.92			U17 vs U19 ($p>.05$)
Flying 20 m (s)	U16	2.51	0.1	2.32	2.67	9.3	<0.01	U16 vs U17 ($p>.05$)
	U17	2.45	0.1	2.31	2.67			U16 vs U19 ($p<.01$)
	U19	2.4	0.05	2.29	2.48			U17 vs U19 ($p>.05$)
CMJFA (cm)	U16	39.29	4.03	32.3	52.1	0.86	>0.05	
	U17	40.39	4.24	32.6	49.7			
	U19	40.82	3.96	35.3	47.9			
CMJ (cm)	U16	33.41	3.73	28.5	44.3	1.43	>0.05	
	U17	34.49	2.92	29.7	39.8			
	U19	35.08	3.17	30.5	40.8			

Note: CMJFA – counter movement jump with free arms, CMJ – counter movement jump

Fig. 1. The relationship between linear running sprint tests (S5 and S10) in monitored age groups

Fig. 2. The relationship between power jump tests in monitored age groups

Figure 3 The relationship between linear running sprint tests (S5 and F20) in monitored age groups

Discussion

Explosive actions such as sprints, jumps and kicks are elementary components of soccer performance (Reilly, 1990) that are often a decisive variable in the result of the game (Cometti et al., 2001; Rienzi, Drust, Reilly, Carter, & Martin, 2000). Since players perform 30 to 40 sprints repeatedly with irregular intervals and at various distances throughout a game (Mohr, Krustup, & Bangsbo, 2003) a player's ability to perform high-intensity physical activities is a relevant predisposition for success (Reilly et al., 2000). Multivariate analysis of variance showed a significant difference in physical performance of soccer players in relation to the age category ($\lambda = 0.471$, $F_{10,110} = 5.03$; $p < .01$, $\eta_p^2 = .31$), while remarkable differences were observed in running tests S5, S10 and F20 (Table), which confirms the fact that age has a significant effect on both absolute and relative intensity of speed actions (Al Haddad, Simpson, Buchheit, Di Salvo, & Mendez-Villanueva, 2015).

In the sprint test at 5 metres we found insignificant differences in time between the players from the

U16 category (1.16 ± 0.05 s) and U17 category (1.15 ± 0.03 s); however, the oldest category (U19) achieved significantly better performance (1.09 ± 0.06 s) compared with both U16 and U17 categories. Some studies presented similar results (Silva, Magalhaes, Ascensao, Seabra, & Rebelo, 2013; Sporis, Jukic, Ostojic, & Milanovic, 2009). Sporis et al. (2009) in their study on Croatian professional soccer players ($n = 270$) pointed out significant deviations in relation to players' field positions. In 10 m sprint, U16 players achieved the poorest performance (1.91 ± 0.06 s) and this time was significantly worse than in U17 (1.85 ± 0.06 s) and U19 categories (1.84 ± 0.07 s). Players from the first French league ($n = 29$) achieved in 10 m running test 1.80 ± 0.06 s (Cometti et al., 2001). Similar results were also observed in Norwegian players (Wisloff et al., 2004) and the best results were observed in players from the English Premier League ($n = 19$, 1.75 ± 0.08 s) (Strudwick et al., 2002). Some studies point out significant differences in sprint performance with respect to players' performance levels (Cometti et al., 2001; Comfort, Bullock, & Pearson, 2012). In French elite players, a significantly higher level of running at 10 m was found in comparison to the players at lower performance level (Cometti et al., 2001). Comfort et al. (2012) compared differences in sprints at 5, 10 and 20 m among professionally trained and recreational rugby players, when no significant difference was found at the distance of 5 m ($p < .05$) but, at greater distances, the trained group achieved significantly better times compared to recreational rugby players, which indicates that relative power is important for initial acceleration in sprint but it relates more closely to the sprint performance at greater distances.

Results in the 20 m flying sprint test ranged as follows: 2.51 ± 0.1 s (U16), 2.45 ± 0.1 s (U17) and 2.4 ± 0.05 s in the oldest tested players (U19). Players from the Czech national team of U16 category achieved the average time of 2.48 ± 0.09 s (Maly et al., 2011) and comparable results were also detected in elite senior players (2.40 ± 0.11 s) (Little & Williams, 2005). In the F20 test, we found a significant difference between U16 and U19 players, when an important role can be seen in the knee flexor's ability to produce the peak torque in the shortest time as well as its absolute strength (Bracic, Hadzic, Coh, & Dervisevic, 2011).

The best performance in the vertical jump (CMJFA) was observed in U19 players (40.82 ± 3.96 cm). On the contrary, the poorest performance was achieved by the youngest players (39.29 ± 4.03 cm); however, this difference was not significant. In the counter movement jump with fixed arms (CMJ), no significant differences among the tested groups were found (Table 1). Lago-Penas, Lago-Ballesteros, and Rey (2011) found better results in adult players from the Belgian Pro League, when the average performance made 40.71 ± 4.6 cm (CMJ) and 43.11 ± 4.9 cm (CMJFA). We did not identify any significant effect of age on vertical jumping performance (CMJFA, CMJ), which can be caused by high heterogeneity of results (inter-individual differences within one age group). This fact can be influenced by a different level of maturation during ontogenesis.

A common physiological basis was confirmed between sprints at 5 and 10 m, when the coefficient of determination ranged between $R^2 = 0.63 - 0.79$ (Fig.1) and jump tests ($R^2 = 0.46 - 0.79$). There are strong correlations between the vertical jump height and speed abilities in sprint at 30 m and this fact indicates that elite soccer players should focus on strength training, with emphasis on maximal mobilization of concentric movements, which may improve their sprinting and jumping performance (Wisloff et al., 2004).

Shalfawi, Sabbah, Kailani, Tonnessen, and Enoksen (2011) tested basketball players and revealed that vertical jumping performance (squat jump, counter-movement jump) has a significant relationship with the running performance at 10, 20 and 40 m. A lower rate of common variance was proved between linear 5 m sprint and maximum running speed in 20 m flying sprint (F20), which points out specificities among the monitored variables.

Conclusions

Field tests that provide specific information about components of sport training are used for identifying components of physical fitness preparedness for young elite soccer players. The results showed a significant effect of age category on field physical performance in soccer players. We found significant age-related differences in linear sprinting performance and, conversely, no significant effect in jump power tests (CMJFA, CMJ) was confirmed. Results of the study point out that despite common physiological speed and power predispositions there are significant age-related differences in running speed and insignificant differences in the vertical jump assessment. These specificities should become an object of further research in young elite soccer players. The results of the test should be useful for a fitness coach from the perspective of feedback about soccer players' fitness level, monitoring the effect of training programmes, return on the performance level during recovery and convalescence, identifying player's weaknesses and planning short-term or long-term training programmes. The results of this study may serve for continuous development of fitness abilities of soccer players during long term monitoring.

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