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Time-motion characteristics of match-play in elite Polish youth soccer players of various playing positions

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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abstract

Background: The aim of this study is to examine and compare the distance covered with high-intensity running and to determine differences in maximum velocities achieved in a match by 15–19-year-old elite Polish soccer players depending on their age and playing positions.

Material and methods: The current study monitored and analyzed 528 matches of youth soccer players of six tactical positions (12 goalkeepers, 24 fullbacks, 24 central backs, 24 wide midfielders, 36 central midfielders and 12 forwards) from four age categories (U-15, U-16, U-17 and U-19) from three top Polish soccer academies, using a MinimaxX device.

Results: It was found that in every age category, central midfielders covered the longest total distance, while wide midfielders covered the greatest distance with high-intensity running. Maximum velocities of players of U-17 and U-19 were significantly higher than players of U-15 and U-16. The highest maximum velocities were achieved by the wide midfielders and forwards of U-19 players.

Conclusions: The selection of players for certain positions in the game must take into account the players' ability to perform high intensity running, sprints and ability to repeat very high intensity running.

Key words: youth players, match analysis, performance analysis, motor preparation, physical load.

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INTRODUCTION

One of the main determinants of efficient game in soccer is the players' suitable motor preparation, which primarily depends on burdening players with appropriate training loads [1]. Their volume and intensity must correspond to the players' level of adaptation to physical effort. This is determined by physiological requirements specified for football players of the best skills in the game [2, 3], and also taking into account their tactical positions in the game [4–9]. Many researchers assume that the length and the intensity of the distance covered during a match are closely linked to the players' motor preparation and determine their sports level [10–14]. It was found that with the passage of the game time the players' motor capabilities decrease. Significant differences in the length of the covered distance, especially in the high-intensity one, were noted between the first and second half of the match, and between the initial and the last minutes of the game [15–18]. In addition, the activity and efficiency of actions with the ball decrease [19–21].

Speed training and, in particular, shaping an ability to perform high-intensity sprints – accelerations, running with the maximum velocity, repeated sprints – is one of the most important elements of a soccer player's motor preparation [22–25]. The listed forms of locomotion are determined by a combination of specific physiological, biomechanical, metabolic and morphological factors, and their development requires a use of different methods and training means [26].

Studies aiming to determine the locomotion requirements for players of various age categories and positions in the game, especially in terms of very high intensity running and maximum velocities, are essential for a rational management of the training process [10, 27, 28, 17, 11, 29]. This requirement is supposed to increase with players' age and degree of sports proficiency. Research on locomotion characteristics in games of young soccer players has been conducted in various countries including Brazil [30], France [31], Italy [32], Qatar [23, 33], and the United Kingdom [34, 35], but very little research data are available concerning analyses of kinematics of young footballers with reference to their position on the field especially when the age group of 15–19-year-olds is considered. Such information is necessary to prepare appropriate training programs for the players of each age group. The significance of such requirements increases with the players' sports experience and their age. Determination of kinematic requirements for the top players allows defining the principles for practical application necessary in conditioning training. Such knowledge is especially important for young players who mature dynamically because it allows for the application of adequate training stimuli.

Therefore, the aim of this study is to compare the distance covered with high-intensity running and to determine differences in maximum velocities achieved in a match by 15–19-year-old elite Polish soccer players depending on their age and playing positions.

MATERIAL AND METHODS

PARTICIPANTS

The subjects included Polish soccer players from the best teams of the Pomeranian province – *Lechia* Gdańsk, *Arka* Gdynia and *Czarni* Pruszcz Gdański in the age categories *Junior C1, B, A* (U-15, U-16, U-17 and U-19). In each age category, matches of 12 goalkeepers, 24 full backs, 24 central backs, 24 wide midfielders,

36 central midfielders and 12 forwards were examined. In total, locomotion of 528 match observations were tracked and analyzed, including observations of 48 goalkeepers, 96 full backs, 96 central backs, 96 wide midfielders, 144 central midfielders and 48 forwards. All players were in systematic training: they participated in five 1.5-hour training units and played a league match during a weekly micro-circle. They also had a current athlete's health card issued by a doctor of sports medicine. In accordance with the guidelines of the Declaration of Helsinki, the subjects and their legal guardians were informed in detail of the research procedures, and they expressed their written consent to conscious participation in the experiment. The Local Bioethical Commission approved of the research.

All the analyzed matches were held in accordance with the rules laid down by the Polish Football Association. The Department of National Tournaments of the Polish Football Association (PZPN) gave written consent to set up the testing apparatus during league matches. In all the analyzed age categories, the league matches took place on a pitch measuring 105 × 68 meters. 11 players from each team played in the matches, and in their course, coaches could substitute 4 players in the Central Junior League (U-17 and U-19) and 7 players in the Pomeranian Junior League B and C1 (U-16 and U-15). The game time was: 2 × 45 min – *Junior A*, 2 × 40 min – *Junior B*, 2 × 35 min – *Junior C1*.

Instrumentation

In the study, the device MinimaxX (version 4.0, Catapult Innovations, Melbourne, Australia) was used. It contains a GPS receiver with a frequency of 10 Hz and a triaxial, piezoelectric linear accelerometer (Kionic: KXP94) that detects movement by means of a micro-electromechanical 100 Hz system. It has its own microprocessor, 1 GB flash memory and a USB interface for recording, storing and sending data. It is powered by a built-in battery with a service life of 5 hours. It weighs 88 g and measures 88 × 50 × 19 mm [6]. The accuracy and reliability using this system to measure actions and movements in team sports have already been validated [36, 37].

Procedures

Before the game, each tested player put on a special tight-fitting vest on which the GPS receiver was mounted at the chest height, between the shoulder blades. The device had been switched on 10 minutes prior to mounting it, before the pre-match warm-up. Results were transferred to a personal computer after match by using Catapult Sprint 5.0 software, Catapult Innovations (2010). Player activities were coded into the following categories and speed thresholds: (1) low-intensity running, from 6 km/h to 18km/h (1.67 m/s to 4.99 m/s); (2) high-speed running and sprinting, from 18 km/h to 25 km/h (5 to 6.93 m/s) and above 25 km/h (6.94 m/s). High-intensity running consisted of high-speed running and sprinting (above 18 km/h or 5 m/s). The speed thresholds for each category are similar to those reported by previous authors [3, 8, 31, 36]. Analysis of the forms of locomotion was conducted for all positions on the pitch: goalkeeper (GK), central back (CB), full back (FB), central midfielder (CM), wide midfielder (WM) and forward (FW). Only those matches were analyzed in which the studied team applied the system of play 1-4-2-3-1. In situations when a player was substituted during a match, the performance of both players was added up.

Statistical analysis

Statistical analysis was developed using Microsoft Excel 2010 and Statistica 10 -StatSoft. Inc. (2011) software. A one-way analysis of variance was employed to compare the difference in means of the total distance (TD) covered, the distance

of high-intensity running (DHIR) covered and the ratio of DHIR/TD by players of the same age category but playing different roles in a match. Another one-way analysis of variance was used to compare the difference in means of the relative total distance (RTD, transferred to the distance covered per minute), relative distance of high-intensity running (RDHIR, transferred to the distance covered per minute) and the ratio of DHIR/TD by players of the same position in the game but who were of different ages. In order to compare the difference in the maximum velocity of the tested players taking into account their age category and tactical position in the game, a two-way analysis of variance was performed in the system of 4 (age) × 6 (position). The significance level was set to $p < 0.05$. The effect size of the two tests was estimated by the partial eta-squared (η_p^2), and the scale was: 0.01 small, 0.06 medium, 0.14 large [38].

RESULTS

The total distance and the distance at high-intensity covered by U15, U16, U17 and U19 elite Polish soccer players of various tactical position in games are presented in Table 1. It can been seen that, in every age category, central midfielders covered the longest total distance, while wide midfielders covered the greatest distance with high-intensity running. By contrast, central backs covered the shortest total distance as well as the shortest distance at a high-intensity level.

Table 1. Total distance and the distance of high-intensity running covered by players of different age categories, taking into account the position in the game

Variables	Age	Position						ANOVA				
		GK (1) [m]	FB (2) [m]	CB (3) [m]	WM (4) [m]	CM (5) [m]	FW (6) [m]	df	F	Sig.	η^2	Post-Hoc
TD	U15	3335 ±317	7932 ±657	7332 ±712	8566 ±596	8715 ±832	8135 ±637	5, 126	159.234	0.000	0.863	1<2,3,4,5,6; 2<4,5; 3<4,5; 6<4,5
	U16	3994 ±434	8482 ±816	8384 ±643	9184 ±531	9163 ±768	8591 ±787	5, 126	50.130	0.000	0.665	1<2,3,4,5,6; 3<5
	U17	4048 ±584	9194 ±787	8538 ±846	9282 ±1816	9715 ±913	8965 ±1255	5, 126	111.158	0.000	0.815	1<2,3,4,5,6; 2<4,5; 3<4,5
	U19	4431 ±671	9897 ±551	9355 ±783	10825 ±663	10935 ±789	9898 ±900	5, 126	122.755	0.000	0.830	1<2,3,4,5,6; 2<4,5; 3<2,4,5,6;
DHIR	U15	15 ±15	598 ±160	210 ±131	651 ±239	432 ±205	508 ±183	5, 126	33.150	0.000	0.568	1<2,3,4,5,6; 2<4; 3<2,4,5,6; 5<4,6; 6<4
	U16	20 ±21	481 ±202	333 ±129	652 ±383	337 ±169	599 ±297	5, 126	20.764	0.000	0.452	1<2,3,4,5,6; 3<2,4; 5<4
	U17	27 ±17	692 ±224	390 ±156	932 ±517	480 ±191	659 ±271	5, 126	15.496	0.000	0.381	1<2,3,4,5,6; 3<4,6; 5<4,6
	U19	20 ±17	773 ±182	497 ±150	1222 ±356	729 ±388	879 ±263	5, 126	31.405	0.000	0.555	1<2,3,4,5,6; 3<2,4,5,6; 5<2,4;
DHIR/TD (%)	U15	0.4 ±0.4	7.5 ±1.9	2.8 ±1.7	7.5 ±2.5	4.8±2.0	6.3 ±2.3	5, 126	33.634	0.000	0.572	1<2,3,4,5,6; 3<2,4,5,6; 5<2,4
	U16	0.5 ±0.6	5.6 ±1.9	3.9 ±1.4	7.2 ±4.5	3.6±1.7	7.1 ±3.8	5, 126	14.599	0.000	0.367	1<2,3,4,5,6; 3<4,6; 5<4,6
	U17	0.6 ±0.4	7.4 ±2.2	4.5 ±1.6	13.2 ±20.3	4.9±1.8	7.3 ±2.4	5, 126	4.348	0.001	0.147	1<2,3,4,5,6; 3<4; 5<4
	U19	0.5 ±0.4	7.8 ±1.7	5.3 ±1.4	11.3 ±3.1	6.6±3.4	8.8 ±2.2	5, 126	34.024	0.000	0.574	1<2,3,4,5,6; 2<4; 3<2,4,6; 5<4;

Table 2 presents the relative total distance, the relative distance covered with high-intensity running and the ratio of DHIR/TD by elite Polish soccer players who played the same position in the game but who were of different ages. As shown in the table, no significant difference was detected in the relative total distance, the relative distance of high-intensity running and the ratio of DHIR/TD for goalkeepers and forwards from different age categories. Full backs of U16 covered a significantly shorter relative total distance, a relative distance of high-intensity running and had a lower ratio of DHIR/TD than their counterparts of U15, U17 and U19. For central backs, their relative total distance covered showed no age difference. However, the relative distance of high-intensity running and ratio of DHIR/TD of U19 central backs were significantly higher than central backs of U15 and U16. Similarly, central midfielders of U19 also covered longer relative distance of high-intensity running and had a higher ratio of DHIR/TD than their counterparts of U15, U16 and U17.

Table 2. Relative total distance and the relative distance of high-intensity running covered by players of different positions in the game according to age category

Variables	Position	Age				ANOVA				
		U15 [m/min]	U16 [m/min]	U17 [m/min]	U19 [m/min]	df	F	Sig.	η^2	Post-Hoc
RTD	GK	48 ±5	50±5	51 ±7	49 ±7	3, 44	0.487	0.693	0.032	
	FB	113 ±9	106 ±10	115 ±10	110 ±6	3, 92	4.566	0.005	0.130	U16<U15, U17
	CB	105 ±10	105 ±8	107 ±11	104 ±9	3, 92	0.378	0.769	0.012	
	WM	122 ±9	115 ±7	116 ±23	120 ±7	3, 92	1.766	0.159	0.054	
	CM	125 ±12	115 ±10	121 ±11	121 ±9	3, 139	5.715	0.001	0.110	U16<U15, U17, U19
	FW	116 ±9	107 ±10	112 ±16	110 ±10	3, 45	1.319	0.280	0.081	
RDHIR	GK	0.2 ±0.2	0.2 ±0.3	0.3 ±0.2	0.2 ±0.2	3, 44	0.711	0.550	0.046	
	FB	8.5 ±2.3	6.0 ±2.5	8.7 ±2.8	8.6 ±2.0	3, 92	6.801	0.000	0.182	U16<U15, U17, U19
	CB	3.0 ±1.9	4.2 ±1.6	4.9 ±2.0	5.5 ±1.7	3, 92	8.820	0.000	0.223	U15< U17, U19; U16< U19
	WM	9.3 ±3.4	8.1 ±4.8	11.7 ±6.5	13.6 ±4.0	3, 92	6.137	0.001	0.167	U15, U16< U19
	CM	6.2 ±2.9	4.2 ±2.1	6.0 ±2.4	8.1 ±4.3	3, 139	9.597	0.000	0.172	U16<U15<U19; U17< U19
	FW	7.3 ±2.6	7.5 ±3.7	8.2 ±3.4	9.8 ±2.9	3, 45	1.516	0.223	0.092	
DHIR/TD (%)	GK	0.4 ±0.4	0.5 ±0.6	0.6 ±0.4	0.5 ±0.4	3, 44	0.521	0.670	0.034	

Descriptive statistics of the maximum velocities achieved in a match by the tested players are shown in Table 3, and the comparison of this parameter accounting for players' age category and their tactical position is presented in Table 4.

Table 3. Maximum velocities (m/s) achieved in a match by the tested players taking into account their age category and position in the game

Position	Age			
	U-15	U-16	U-17	U-19
GK	5.4 ±0.5	5.7 ±0.6	5.7 ±0.3	5.6 ±0.7
FB	7.3 ±0.4	7.3 ±0.4	7.5 ±0.4	7.8 ±0.5
CB	6.7 ±0.7	7.2 ±0.5	7.4 ±0.5	7.5 ±0.6
WM	7.4 ±0.4	7.5 ±0.3	7.5 ±0.3	8.3 ±0.3
CM	6.9 ±0.5	7.0 ±0.7	7.3 ±0.6	7.5 ±0.4
FW	7.3 ±0.7	7.3 ±0.6	7.6 ±0.5	8.0 ±0.3

Note: Data are presented as "mean ± standard deviation". GK – goalkeeper, FB – full back, CB – centralback, WM –wide midfielder, CM – central midfielder, FW – forward.

Table 4. One-dimensional tests of significance for the maximum velocity of players taking into account their age category and tactical position in the game

Source	Type III SS	df	Mean Square	F	Sig.	η^2
Corrected Model	197.625	23	8.592	33.079	0.000	0.602
Intercept	22969.892	1	22969.892	88430.366	0.000	0.994
Position	156.649	5	31.330	120.614	0.000	0.545
Age	24.800	3	8.267	31.825	0.000	0.159
Position * Age	8.316	15	0.554	2.134	0.008	0.060
Error	130.915	504	0.260			
Total	27887.580	528				
Corrected Total	328.540	527				

A significant difference in the maximum velocities was not found between the players of U-15 and U-16, while the maximum velocities of players of U-17 and U-19 were significantly higher than players of U-15 and U-16; meanwhile, players of U-19 achieved the highest maximum velocities among all the age groups (see Figure 1). Considering the tactical positions, goalkeepers achieved the lowest maximum velocities in a match with no doubt, while full backs, wide midfielders and forwards achieved significantly higher maximum velocities than central backs and central midfielders (see Figure 2). The interaction effects of "Position * Age" showed that the highest maximum velocities were achieved by the wide midfielders and forwards of U-19 players, while the lowest maximum velocities were achieved by the central backs and central midfielders of U-15 players (yet goalkeepers of all ages had significantly lower values).

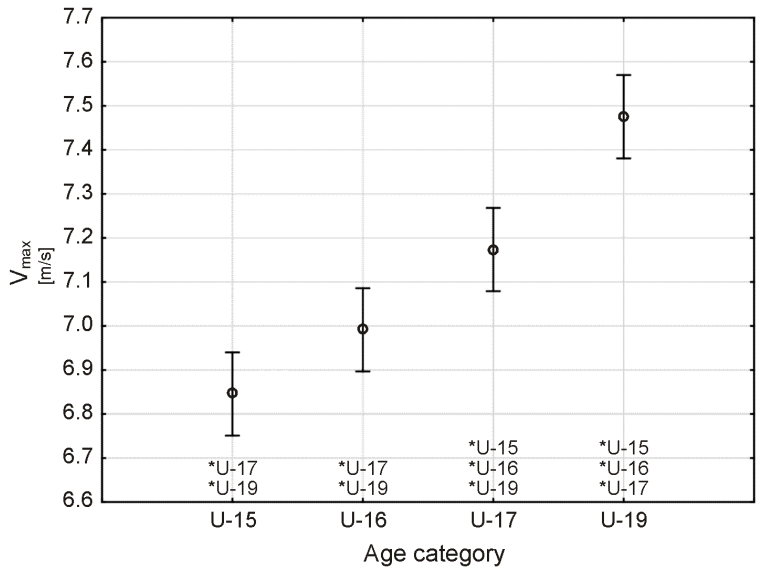

Fig. 1. Maximum velocities (V_{max}) achived in match by the tested players taking into account their category (dots are means, error bars are standard deviations, "*" denotes differences statistically significant at $p < 0.05$)

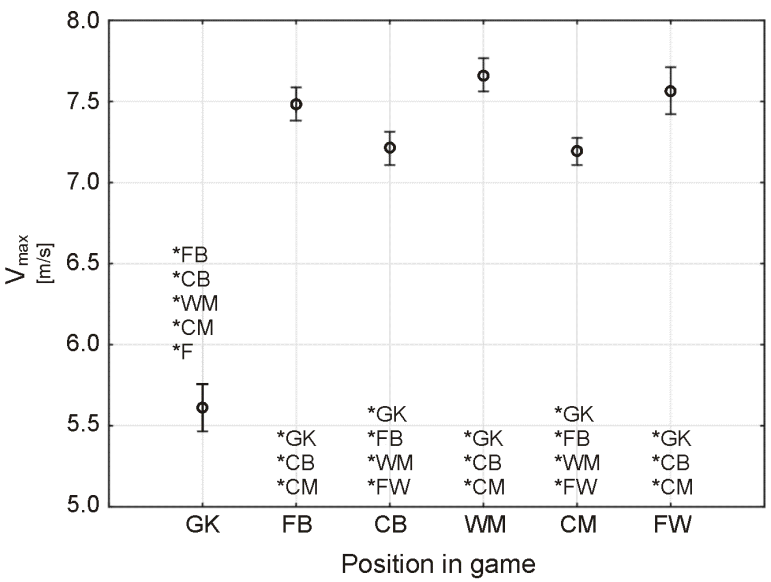

Fig. 2. Maximum velocities (V_{max}) achived in match by the tested players taking into account their tactical position in game (dots are means, error bars are standard deviations, „*" denotes differences statistically significant at $p < 0.05$)

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DISCUSSION

Our research shows that players in older age categories playing in all positions in the game covered a longer total distance than players from younger age categories. Harley [35] noted a similar trend in their research on players in the U12–U16 categories. In addition, we found that, on average, the longest distance was covered in the following order by: central midfielders, wide midfielders, forwards (with the exception of the U17 category, where full backs covered a longer distance than forwards did), full backs, central backs. Studies [27, 10, 7, 20, 29] conducted by previous authors on senior groups are in accordance with our findings. Their research shows that the longest total distance is always covered by players from the positions of either the central or the wide midfielder, followed by the full back or the forward, while the shortest ones by the central back. Obviously, due to the specificity of the game, goalkeepers cover a statistically different distance from players of the remaining positions. It seems that the total distance covered by the players in a game is not a characteristic feature of their sports level. The players of the oldest age category (U19) examined in this study on average covered 10,182 m in a match, which is similar to the distance covered by senior professional footballers: English ones 11,080 m [39], Spanish ones 10,790 m [40], and Brazilian ones 10,071 m [4].

The present study has proven that wide midfielders, forwards and full backs in all the investigated age categories covered the longest distance with very high intensity running in relation to the entire distance registered in a match. Clearly lower values were noted among central midfielders, central backs, and obviously, goalkeepers. It has been observed that the higher the players' age category is, the bigger the value of this indicator for the all examined positions becomes. Examining players from the U12 to U16 categories, Harley [35] indicated that the U16 players cover a statistically longer distance with high intensity running and sprinting than the younger footballers (U12, U13). In contrast, Buchheit [23] showed that among footballers of age 13 to 18, the players of younger age categories performed more and longer sprints per sequence than the older players (when using relative speed thresholds), and players from the wide midfielder, forward and full back positions achieve more sprints than those from the remaining positions. Meanwhile, studies on adult soccer players showed that wide midfielders, forwards and full backs cover a significantly longer distance with high intensity running than players of the remaining positions [10, 27, 41, 20, 16, 41, 8]. In other words, the longest distance is covered with high intensity running by players who, due to their position in the game, operate on a large area of the playing field. These are wide midfielders, forwards and full backs, and the differences between them and players of the other positions are the greater, the older the players' age category. Hence, the selection of players for the outermost positions in the game should take into account their motor predispositions in this regard.

A comparison of the results obtained by players of the oldest age group (U-19) with achievements of professional football players is very interesting. The examined here 19-year-olds achieved higher average values of maximum velocities (except central midfielders) (goalkeepers – 5.6 m/s; full backs – 7.8 m/s; central backs – 7.5 m/s; wide midfielders – 8.3 m/s; central midfielders – 7.5 m/s and forwards – 8 m/s) than the results of English players of the top division (full backs – 4.8 m/s; central backs – 7.3 m/s; wide midfielders – 4.9 m/s; central midfielders – 7.5 m/s and forwards – 4.8 m/s) [35]. These surprising results can only be explained by the fact that in the two studies, different tools for data collection are used (the GPS system used by us was much more accurate). It is worth adding that the highest

values of the maximum velocity were achieved by players who had more space to operate in due to their position in the game. Wide midfielders, forwards and full backs performed the most sprints, and simultaneously, they covered the longest distance with this form of locomotion, which authenticates our earlier statement on the distance covered with high intensity running. Therefore, the selection of players for certain positions in the game must take into account the players' ability to perform high intensity running, jumping [42] and sprints and also, as proved by Aziz [22], Bradley [10, 27], Buchheit [23] and Carling, Le Gall and Dupont [43] the players' ability to repeat very high intensity running. In this context, Bangsbo, Mohr and Krustrup [2] suggestion to use the results of motor tests in sprints at the distance 20 m, 30 m and 40 m as a selection criterion for certain positions in the game still remains topical.

CONCLUSIONS

Players who, due to their position in the game, operate on a larger area of the playing field, i.e. wide midfielders, forwards and full backs cover the longest distance with high intensity running and achieve the highest values of the maximum velocity. The differences between them and players of the other positions are the bigger, the older the players' age category. Therefore, in the selection of players for the outermost positions in the game, one should take into account their motor predispositions in this regard, and motor training should be individualized in terms of the positions they take. The importance of these requirements should increase with the players' age and the degree of their sports proficiency.

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