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MOTOR PERFORMANCE AS A FACTOR OF LIMITING MOTOR CAPABILITIES OF SOCCER PLAYERS

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Key words: global positioning system, parameters of inertial high-intensity movement, motor performance, functional assessment of movement, motor capabilities, soccer players.

Annotation. The purpose of the study is to study the GPS parameters, measured by inertial units, of motor performance as factors limiting the motor capabilities of soccer players, determined by the test values of the functional movement screen (FMS). 40 soccer players (age 16,8±2,.1 years; height 168,8±1,6 cm, weight 69,5±5,3 kg) were tested in training sessions (n=149) using the Catapult global positioning system (Optimeye S5; Catapult Innovations of Australia, Melbourne). The parameters of inertial high-intensity movement (IMA High>3,5 m/s^{-1}) were recorded: acceleration (IMA acceleration High), deceleration (IMA deceleration High), change of direction to the left (IMA Cod Left High), change of direction to the right (IMA Cod Right High), jumps (IMA jump High). Functional motion screen (FMS) was performed twice during the study period. The diagnosis included 7 test exercises, in each of which the athlete could get from 0 to 3 points. There was a strong inverse correlation between the acceleration parameter and the FMS test exercises: the rotary stability of the right side (r=-0,917, P=0,018) and the overall score (r=-0,844, P=0,011); a strong direct correlation between the inertial high-intensity deceleration indicator and the FMS test scores: deep squat (r=0,759, P=0,013), hurdle step with the right foot (r=0,713, P=0,015), in-line lunges on the left (0,863, P=0,016) and right (r=0,879, P=0,011) legs, rotary stability of the right side of the athletes' body (r=0,749, P=0,013), overall score (r=0,.753, P=0,015); between inertial high-intensity changes of directions to the left and FMS test exercises: in-line lunge on the right leg (r=0,713, P=0,014), active raise of the right straight leg (r=0,935, P=0,011), mobility of the left side of the shoulder (r=0,717, P=0,014), overall score (r=0,912, P=0,012); between the indicator of high-intensity inertial changes of direction to the right and FMS test “in-line lunge on the left leg” (r=0,912, P=0,012); between jump-based inertial high-intensity activity and test scores in the following exercises: deep squat (r=0,827, P=0,012), hurdle step

(r=0,771, P=0,013), mobility of the left shoulder (r=0,986, P=0,011). The parameters of inertial high-intensity movement (IMA High>3,5 m/s^{-1}) can be considered as factors limiting the motor capabilities of soccer players. The most significant functional deficiencies are manifested in tasks related to deep squats, trunk stabilization and mobility of the lower limbs, as well as a large prevalence of asymmetry of the right and left sides of the body.

Introduction. Movement is a complicated process, during which the effectiveness is achieved at the expense of minimal energy costs, effortful control and other expenses from different organism systems. The hypoexitability of agonist muscles lies in the basis of genetically conditional locomotion. Their functional weakness is due to hyperactivity of other muscle groups, which is a significant factor of limited motor realization [1-4]. Movement disorganization is accompanied by redistribution of loads in parts of the kinematic chain, and the muscle imbalance forms. Disruption of movement asymmetry in soccer has a high correlation to injuries of the musculoskeletal apparatus [5-6]. For this reason, not only rehabilitation events step forward, but also events that allow for quick and effective early monitoring survey and diagnostics, which can reveal an overload of the musculoskeletal system of soccer players in advance. Modern GPS-technologies allow implementing an analysis of motor performance of players on soccer field using space- and time-based characteristics [7]. However, change of body's location in space does not fully show a specific character of soccer players' motor performance. Additional equipage of GPS with such microsensors as gyroscopes, magnetometers and accelerometers allows us to gather data, based not on the athlete's body positioning, but on the changing projection of apparent acceleration [8]. One of those variables are indicators of the Inertial Movement Analysis (IMA), which are described as momentary one-step physical efforts of different capacity [6].These movements are shown during accelerations, decelerations and changes of directions (Cod), common to team games, soccer in particular.

The purpose of the study is to study the GPS parameters, measured by inertial units, of motor performance as factors limiting the motor capabilities of soccer players, determined by the test values of the functional movement screen (FMS).

Methods and organization. We studied functional capabilities of soccer players (n=40, age 16,8±2,1 years; height 168,8±1,6 cm, body mass 69,5±5,3 kg) during training sessions (n=149). Every participant gave a spoken consent to participate. Monitoring survey of the motor performance of soccer players was carried out using the Catapult global positioning system (Optimeye S5; Catapult Innovations of Australia, Melbourne). Technology includes a mini device, built with microsensors, accelerometer, magnetometer and gyroscope; elastic jacket; movable case, which integrates data on locomotor load from mini devices into the cloud-based analytical platform OpenField for their analysis and storage (Fig. 1). The parameters of inertial high-intensity movement (IMA High>3,5 m/s^{-1}) were recorded: acceleration (IMA acceleration High), deceleration (IMA deceleration High), change of direction to the left (IMA Cod Left High), change of direction to the right (IMA Cod Right High), jumps (IMA jump High). The analysis of inertial movement is based on patented scientific research results, based on forming the non-gravity vector, as well as on the use of the advanced Kalman filtering algorithms for the qualitative assessment of the local movement frequency. Registration of IMA-movements is carried out using splines between the initial and final points of accelerating events and is calculated by summing up physical efforts, measured as delta-speed, and multiplied by the impulse unit (m/s^{-1}) [9].

The functional movement screen (FMS) was performed at the beginning and at the end of the study, which included 7 tests and allowed us to make a qualitative assessment of motor capabilities of soccer players (Fig. 2) [1]. Each athlete performed following physical exercises: deep squat, hurdle step, in-line lung, shoulder mobility, active straight leg raise, trunk stability push-up, rotary stability. The equipment set for FMS testing includes: a 150x10x3 cm measuring board, a body bar, a measure tape and a hurdle with height changing (Fig. 3). The evaluation system was implemented in compliance with developers' recommendations [10]. 3 points – a correct motor performance, without compensatory movements, loss of balance etc.; 2 points – the test is performed with compensatory movements or in easy version; 1 point – the test is not performed or not performed fully; 0 points – feeling pain when performing the test. It is needed to note that the highest amount of points in this testing system is 21. Athletes performed three attempts of each test, the best result was recorded. If there were doubts in the evaluation, the worst result was recorded. There are three tests in the FMS testing, which are evaluated according to the binary system "positive/negative" (+/-). If the test is positive (the athlete feels pain), the corresponding test is evaluated as zero (0).

A hypothesis of data correlation was tested using the Spearman correlation analysis (r). The regression analysis was used to study motor performance, shown as inertial high-intensity movements, in training sessions. Reliability of differences between point values of the functional movement screen (FMS) was defined using the Wilcoxon t-test. If $p<0,05$, differences were considered as significant. The statistical analysis was carried out in application programs "STATISTICA 12.0" и "Microsoft Office Excel 2017".

Fig. 1. Portable case with GPS-devices, elastic jacket, cloud-based analytic platform OpenField (Optimeye S5; Catapult Innovations of Australia, Melbourne)

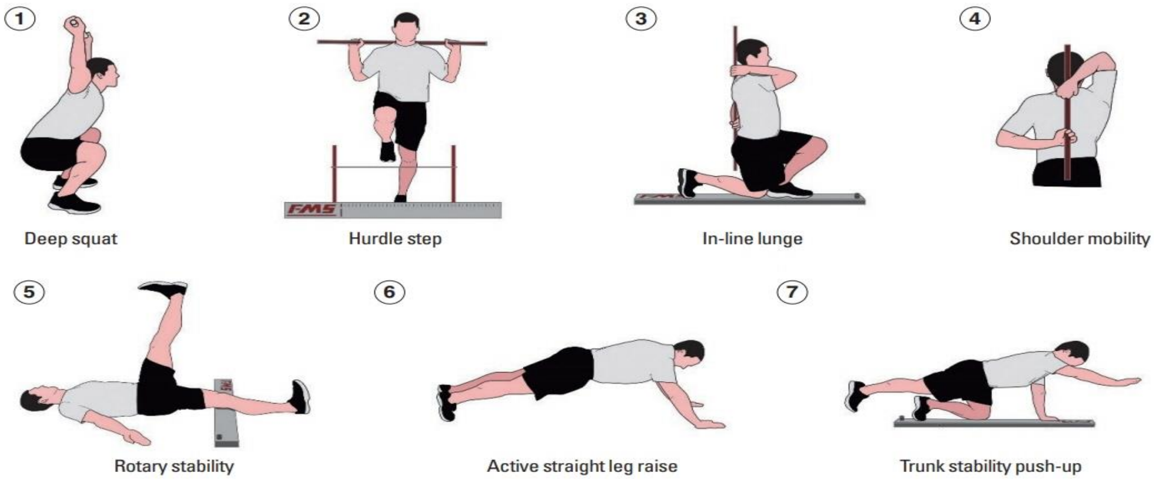

Fig. 2. Physical exercises used in the Functional assessment of movement (FMS)

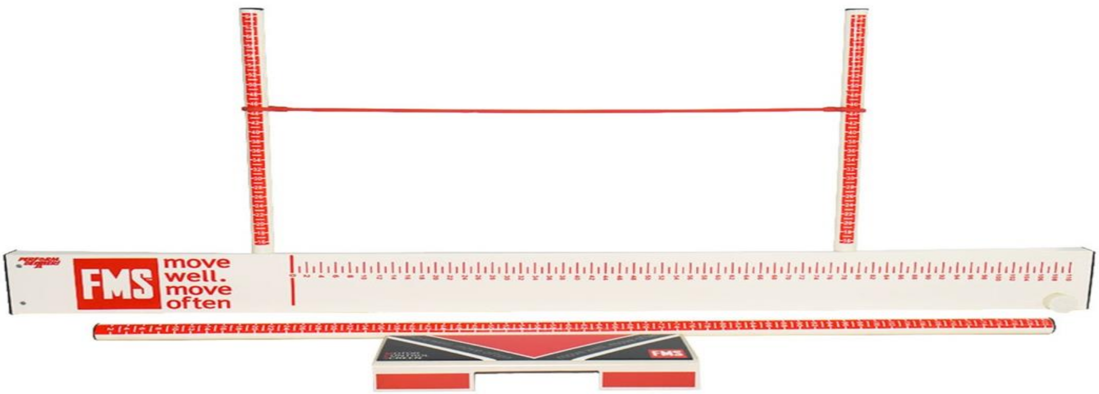

Fig. 3. Equipment set for FMS testing

Results and discussion. The first diagnostics testing showed that the initial background of the functional state of the musculoskeletal apparatus of the examined selection differs from the coordinated mobility of limbs combined with the high level of deep muscles (Fig. 4). The analysis of indicators of the functional evaluation of movement before examining the effect of the external factor, which is the motor performance, evaluated with inertion units, did not reveal disruptions and changes in the locomotor function, implemented by elbow joints and the muscular system of soccer players (Table 2).

The study results of the relation between examined indicators are presented in Table 1. The amount and tempo of decreasing dynamics of high-intensity intertion accelerations (Fig. 2) determine a strong inverse correlation with FMS test exercises: the rotary stability of the right side (r=-0,917, P=0,018) and the overall score (r=-0,844, P=0,011). Physical efforts decreased by 0,014 c.u., when implementing the locomotor function of the maximum capacity in relation with each training session. A regression equation for this indicator is as follows: intertial high-intensity accelerations =-0,014*149+11,652. A strong direct correlation was found between the inertial high-intensity deceleration indicator and FMS test results: deep squat (r=0,759, P=0,013), hurdle step with the right foot (r=0.713, P=0.015), in-line lunges on the left (0,863, P=0,016) and right (r=0,879, P=0,011) legs, rotary stability of the right side of the athletes' body (r=0,749, P=0,013), overall score (r=0,753, P=0,015). A regression equation for this indicator is as follows: inertial high-intensity deceleration = 0,0276*149+9,8263. Fig. 7 shows more stable dynamics of inertial high-intensity direction changes to the left and to the right in the training activity of soccer players.

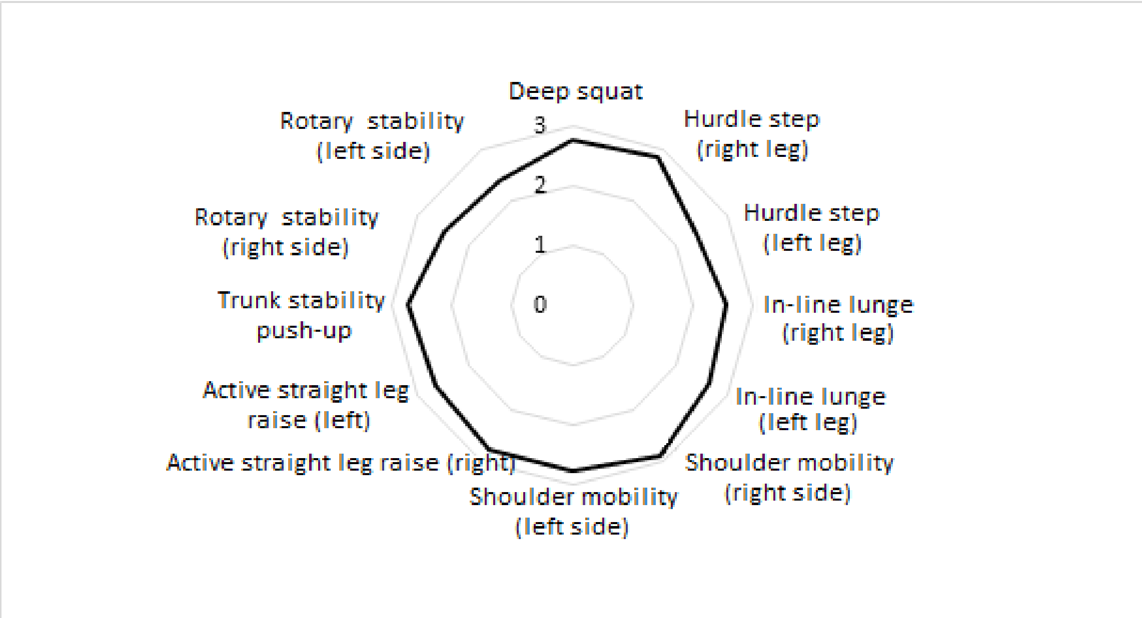

Fig. 4. Initial values of the functional evaluation of soccer players’ movement

Table 1

Correlation between FMS test points and GPS parameters in the second examination

FMS tests		GPS indicators				
		Accelerations	Decelerations	Direction changes		Jumps
				to the left	to the right	
Deep squat		0,344 P=0,117	0,759* P=0,013	0,119 P=0,325	0,514 P=0,344	0,827* P=0,012
Hurdle step	right leg	0,363 P=0,766	0,713* P=0,015	0,683 P=0,288	0,242 P=0,214	0,771* P=0,013
	left leg	-0,677 P=0,711	0,754 P=0,123	0,442 P=0,641	-0,278 P=0,103	0,603 P=0,277
In-line lunge	right leg	0,242 P=0,851	0,879* P=0,011	0,713* P=0,014	0,344 P=0,435	0,278 P=0,662
	left leg	0,223 P=0,241	0,863 P=0,016	0,491 P=0,753	0,912* P=0,012	0,177 P=0,373
Shoulder mobility	right side	-0,118 P=0,112	0,431 P=0,231	0,212 P=0,101	-0,214 P=0,301	0,311 P=0,114
	left side	0,345 P=0,198	0,818 P=0,031	0,717* P=0,014	0,638 P=0,642	0,986* P=0,011
Active straight leg raise	right	-0,429 P=0,499	0,529 P=0,439	0,935* P=0,011	0,333 P=0,296	0,486 P=0,129
	left	-0,111 P=0,217	0,231 P=0,315	0,442 P=0,316	-0,466 P=0,208	0,571 P=0,166
Trunk stability push-ups		-0,655 P=0,144	0,779 P=0,134	0,598 P=0,239	-0,388 P=0,178	0,198 P=0,229
Rotary stability	right side	-0,917* P=0,018	0,749* P=0,013	0,073 P=0,187	-0,145 P=0,739	0,733 P=0,628
	left side	-0,216 P=0,337	0,347 P=0,451	0,512 P=0,213	-0,411 P=0,172	0,464 P=0,192
Overall score		-0,844* P=0,011	0,753* P=0,015	0,861* P=0,012	-0,028 P=0,476	0,786 P=0,331

Note: *- differences are significantly reliable (p<0,05)

The data analysis demonstrates a tendency of increasing mechanical load by 0,1091 c.u. in case of motor implementation with changes in the vector of direction to the left (Fig. 6). This characteristic has a strong direct correlation with FMS test exercises: in-line lunge to the right leg (r=0,713, P=0,014), active straight raise of the right leg (r=0,935, P=0,011), mobility of the shoulder's left side (r=0,717, P=0,014) and overall score (r=0,912, P=0,012). A regression equation for this indicator is as follows: inertial high-intensity changes of direction to the right =0,002*149+2,3588. Tendency of the jump-based inertial activity increased by 0,0359 units in relation to each training session (Fig. 7). A strong direct correlation of this indicator was registered in following test exercises: deep squat (r=0,827, P=0,012), hurdle step (r=0,771, P=0,013), and the mobility of the shoulder's left side (r=0,986, P=0,011). A regression equation for this indicator is as follows: inertial high-intensity jumps =0,0359*149+6,0916.

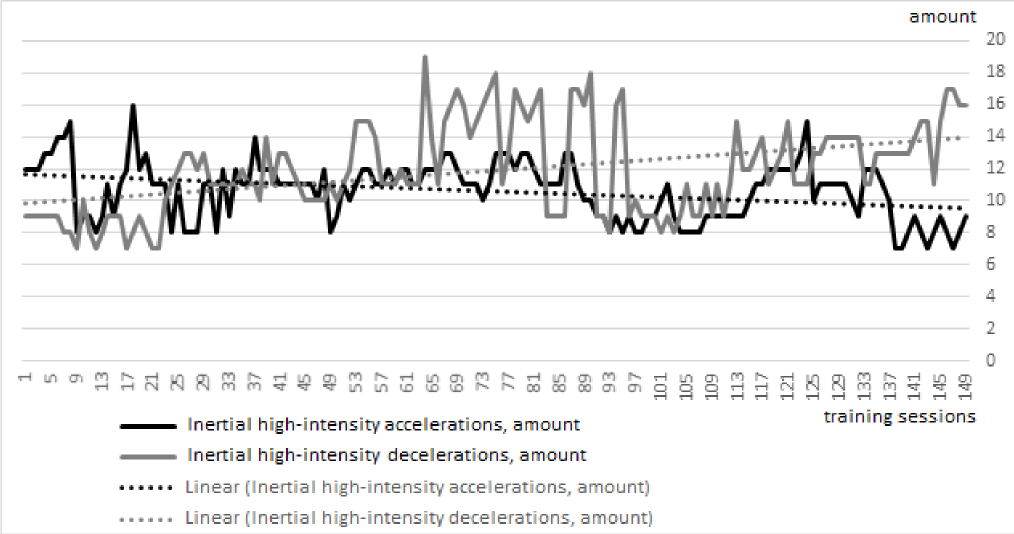

Fig. 5. Changes in indicators of inertial high-intensity accelerations and decelerations in training sessions

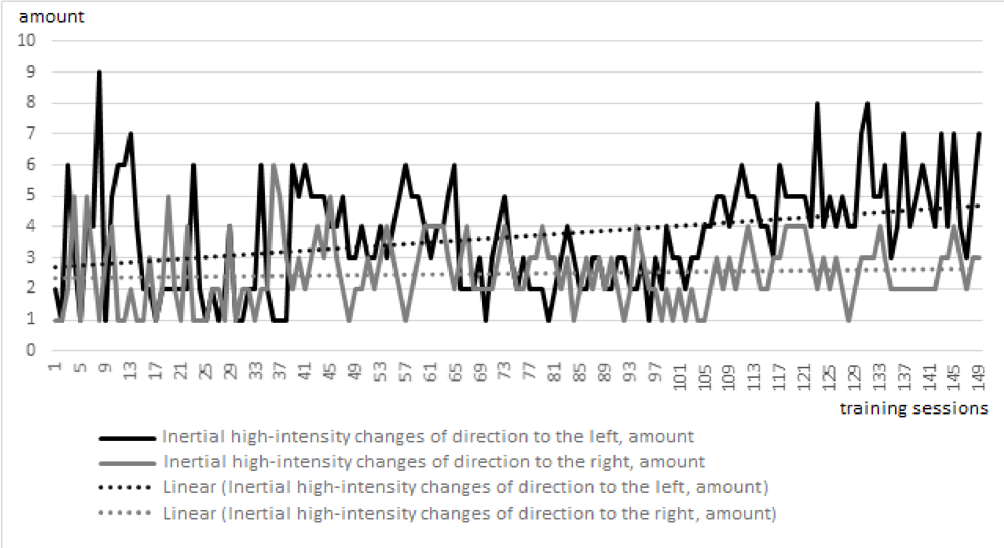

Fig. 6. Changes in indicators of inertial high-intensity changes to the left and to the right in training sessions

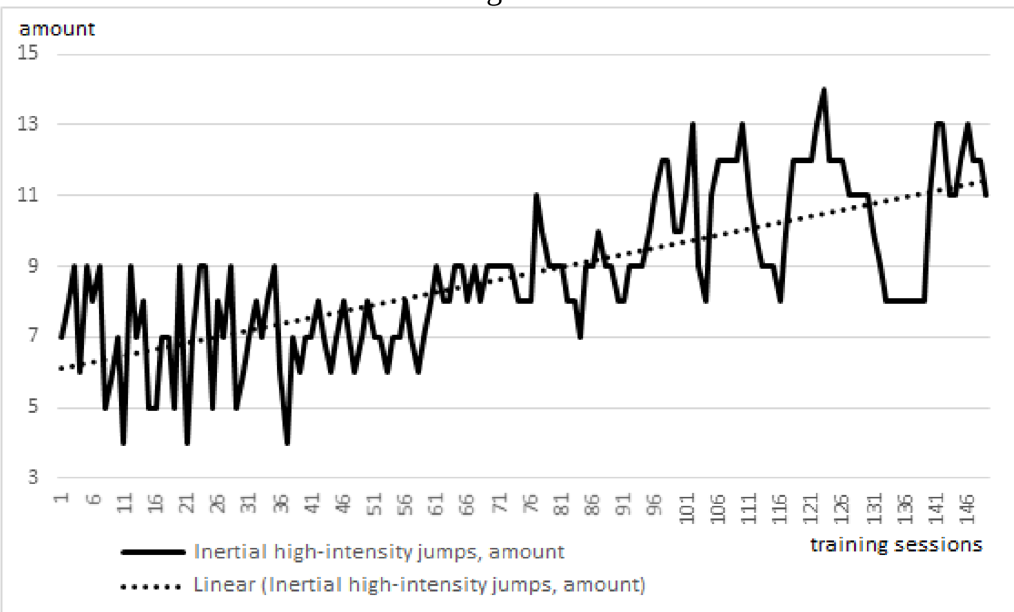

Fig. 7. Changes in the inertial high-intensity jumps indicator in training sessions

Table 2 presents significant (p<0,05) differences between FMS test results. Mechanical load made a significant effect (p=0,021) on a decrease of points in the "deep squat" test. Uncoordinated mobility of limbs combined with a non-stable stability showed a limited amplitude of evaluated movement. Weak stability of the support leg and non-optimal mobility of motor function in the hip joint while making a hurdle step (right side) were notable signs of significant (p=0,037) low evaluation. When performing the in-line lunge (right side), a tremor in maintaining the given pose and when extending knee and hip joints was registered. Differences are significant between the first and the second measurement. The level of shoulder mobility (left side) was significantly (p=0,033) decreased and accompanied by limitation of movement in the chest and shoulder in athletes of this selection. We suggest that low points, obtained in this test, are related to the dysfunction of the scapulothoracic joint and the shortening of muscles in this area. The active straight leg raise (right leg) turned out to be complicated for athletes, specialized in soccer. The sensible discomfort when performing this movement, low elasticity of soft tissues of the hip's posterior surface and the hip joint asymmetry served as signs of significantly (p=0,019) low FMS points. Limited motor capabilities along the whole kinematic chain of the musculoskeletal apparatus joints complicate the functional implementation of the "rotary stability (right side)" test (p=0,012).

Table 2

Results of the FMS of soccer players (n=40)

Test	1 diagnostics M±SD	2 diagnostics M±SD	Z	P
Deep squat	2,74±0,16	2,29±0,22	-1,201	0,021
Hurdle step (right leg)	2,87±0,23	2,48±0,14	2,047	0,037
Hurdle step (left leg)	2,39±0,09	1,67±0,84	1,028	0,563
In-line lunge (right leg)	2,58±0,44	2,13±0,07	2,064	0,023
In-line lunge (left leg)	2,62±0,16	2,18±0,04	2,201	0,087
Shoulder mobility (right side)	2,89±0,33	2,86±0,19	-1,991	0,312
Shoulder mobility (left side)	2,77±0,31	1,92±0,23	2,302	0,033
Active straight leg raise (right)	2,76±0,13	1,63±0,18	1,087	0,019
Active straight leg raise (left)	2,65±0,11	2,51±0,23	3,076	0,111
Trunk stability push-ups	2,74±0,24	2,62±0,12	1,539	0,347
Rotary stability (right side)	2,47±0,37	2,37±0,51	3,098	0,012
Rotary stability (left side)	2,39±0,06	2,29±0,05	2,045	0,331
Overall score	17,20±2,12	14,09±1,72	-1,121	0,023

Note: *- differences are significantly reliable (p<0,05)

Box diagrams on fig. 9 and significant (p=0,023) data in table 2 show substantial differences in FMS overall score after examining the separate effect of different factors (inertial high-intensity motor activity). Combined signs present functional disadvantages of motor capabilities of soccer players – the limited mobility of the body, shoulder and the chest area of the spine. A decrease of the functional mobility of lower extremities, due to the limited flexion and extension function of the hip joint, was registered. An asymmetrical leg positioning was also observed.

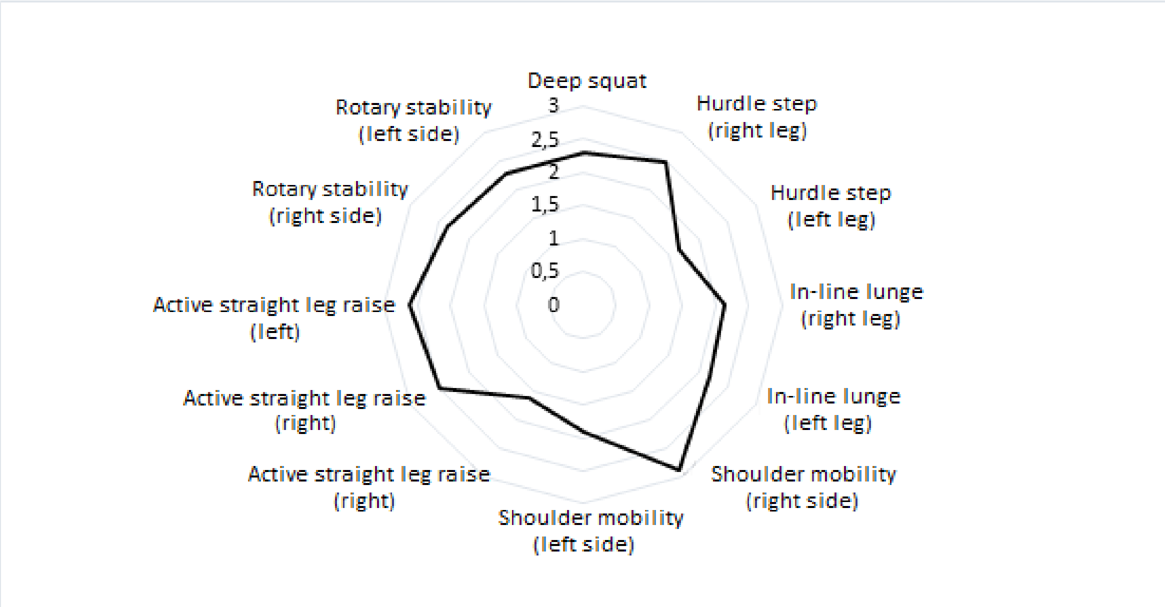

Fig. 8. Results of repeated FMS of soccer players

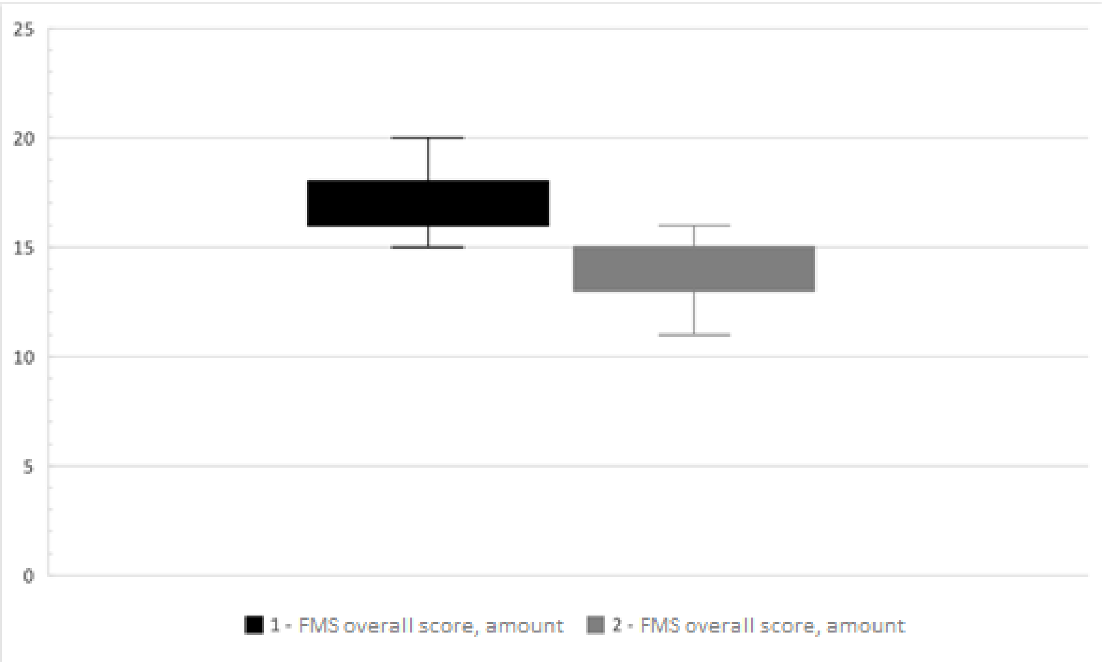

Fig. 9. The ratio of FMS evaluations

Conclusion. The conducted study allows giving recommendations for using parameters of the inertial high-intensity movement (IMA High>3,5m/s^{-1}) as indicators of the motor performance of soccer players. A dynamic monitoring survey of IMA parameters, as well as their comparison with results of FMS test exercises revealed that the increase of decelerations, jumps and changes of directions to the left and to the right can be considered as separate factors, limiting motor capabilities of soccer players. We also revealed that the highest functional limitations are shown in tasks related to a performance of deep squats, trunk stabilizing and mobility of lower limbs, as well as the presence of motor asymmetry of the left and right sides of the body.

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