Original paper

Fizjoterapia / Physiotherapy 2016, 24 (2), 13–18

Assessment of fundamental movement patterns and risk of injury in male soccer players

DOI: 10.1515/physio-2016-0008

Stanisław Gadziński[1], Agata Masłoń[1], Dorota Czechowska[1], Joanna Golec[1], Elżbieta Szczygieł[1], Edward Bogusław Golec[1, 2]

[1] University of Physical Education in Kraków, Poland
[2] 5th Military Hospital with Polyclinic in Kraków, Poland

Abstract

Introduction. The aim of the study was to assess the functional status of male soccer players in different age groups who played on different surfaces.
Methods. The study included 45 soccer players aged 13–35 years. Among them, 15 were junior players, 15 were players of the senior Silesia-Opole 3rd league (SL), and 15 were senior players in the futsal Extra Class league (SF). The functional status and basic motor skills were assessed according to the results obtained in seven motor tasks included in the Functional Movement Screen™ (FMS) test.
Results. The mean total scores in the FMS test were statistically significantly higher among both senior futsal and senior 3rd league players than among junior players. However, there were no significant differences between the results obtained by the two senior groups (SL and SF). Seniors achieved higher scores in most of the assessed tasks, but they performed significantly better than juniors only in the trunk rotary stability test. Juniors obtained correct results in the active straight leg raise trial significantly less frequently, but only in comparison with the SF group. Differences were also observed between the teams of seniors playing on different training surfaces (grass vs. hard floor).
Conclusions. Senior players (those who played on grass as well as on hard floor) demonstrated a better functional status than juniors. Fewer deficits in fundamental movement patterns were identified in the SL group than in the SF group.

Key words: soccer, futsal, Functional Movement Screen, movement fundamentals, training surface

Introduction

Soccer is one of the most popular sports disciplines in the world. In order to meet its requirements, contemporary soccer players undergo extremely rigorous training. Excessive training load leads to load-related changes and injuries that often hamper a player's career or even terminate it prematurely. Consequently, many people engaged in sports face the key issue of how to effectively improve the players' motor, tactical, and technical skills while minimizing the risk of injury and preventing overload. To address this concern, increasingly greater attention is paid to such matters as prevention, individualization of training, or regular and thorough monitoring of the players' health. Many sports clubs and organizations introduce prophylactic programs that involve standardized procedures aimed at reducing the risk of injury [1]. An individual approach is also crucial, as each player constitutes a separate part of the team and often displays considerably different tolerance for load and different shortcomings in a given motor skill [2]. This fact must be taken into account when planning the training cycle, especially in team sports. This, however, requires an individual assessment of a player's functional capabilities and potential risks to the motor system [3].

An extremely important aspect of safe training is proper periodicity. The aim of periodicity is to combine different training methods into particular programs, to achieve an optimal progression of load during a given stage of the macrocycle, and, equally importantly, to prevent injury [4].

Many studies confirm the high reproducibility and comparativeness of functional assessments that use the Functional Movement Screen™ (FMS) test among different samples [2, 5–7]. The proposal to apply FMS for functional assessment came from American physical therapists Cook and Burton [8, 9]. The main goal of the FMS test is to identify persons with an increased risk of injury to the motor system, determine asymmetries, and, subsequently, establish the procedure (i.e. introduce appropriate corrections or load progression) [2, 8, 9]. A given deficit (i.e. the weak link) affects all other links in the biokinetic chain, leading to overload. The qualitative assessment of motion helps to determine particular motor limitations and improve performance at a given motor task, which in turn adds to the development of the quantitative parameters of motion (higher levels of the motor preparation pyramid) [3, 8].

Factors that may definitely affect basic motor skills in soccer players are age and the related experience. Among the risk factors for sports injury in children and youth, the subject literature lists a different structure of the nervous, hormonal, and musculoskeletal systems (higher porosity and plasticity of the bones, looser ligaments, and incomplete bone growth) than in adults, mental characteristics (including a low attention span, undeveloped hand-eye coordination, low awareness, and low motivation for motor training), changes in body proportions, and considerable differences in physical fitness and growth rate between children of the same age [10]. In turn, risk factors for sports injury in adults include lowered elasticity of soft tissues, lowered neuromuscular control, and lowered bone density.

The functional status of soccer players may also depend on the training surface (grass or hard floor at a sports hall) [11].

This study analysed the functional status of male soccer players who represented different levels of skill and trained on different surfaces, in the context of detecting a potential risk of injury of the motor system. The aim of the study was to determine whether there were differences in the functional status and, consequently, in the risk of injury among soccer players depending on skill and surface, and to indicate any deficits among the players.

Subjects and methods

Subjects

The study included 45 soccer players of the Beskids Sports Association club, Rekord Bielsko-Biała, at different levels of skill, aged 13–35 years (mean age, 21.2 years). The inclusion criteria for the study were regular participation in training within the preceding 12 months and no injury (defined as a state that prevents active participation in training for at least 7 days) within the preceding 4 weeks. From among the group of 50 study participants 5 persons sustained injuries within the preceding 4 weeks and were thus excluded from the study. Among the study participants, 15 were junior players (born in 2002), 15 were seniors from the futsal Extra Class league (SF), and 15 were seniors from the Silesia-Opole 3rd league (SL). Only the SL group trained on natural grass. The other two groups trained on an artificial surface. Table 1 provides the detailed characteristics of the study participants.

All study participants were informed about the procedure and aim of the study. They provided their written consent for participation, and filled a questionnaire concerning their basic personal and anthropometric data. The participants were also informed that they could opt out of the study at any point.

Table 1. Basic anthropometric data of the study participants

		Mean	Min	Max	*SD*
Juniors	Age	13.00	13	13	0.00
	Body height	164.27	147	176	8.15
	Body weight	53.87	38	70	8.73
	BMI	19.86	16.33	22.72	1.99
Seniors (3rd league)	Age	24.34	18	33	4.17
	Body height	179.94	167	191	6.49
	Body weight	76.20	65	89	8.20
	BMI	23.75	20.83	25.40	1.19
Seniors (futsal)	Age	26.34	17	35	4.83
	Body height	176.60	166	186	6.12
	Body weight	76.00	65	87	6.67
	BMI	24.36	22.28	27.99	1.54

Methods

The study was conducted in Bielsko-Biała, Poland, at the 'Record' training facility during the winter break between seasons (from February 1 to March 28, 2015). Fundamental movement patterns were assessed in accordance with the guidelines developed by Cook, the author of the FMS method. The assessment employed the FMS set as outlined in the protocol proposed by its developers [8, 9]. The FMS set includes a 150 × 15 × 10 cm base, a pole of ca. 150 cm in length, and a hurdle (two poles of ca. 50 cm in length each and a rubber band).

Each participant underwent 7 scored trials that are part of the FMS test: (1) deep squat (DS) (Figure 1), (2) hurdle step (HS) (Figure 2), (3) in-line lunge (IL) (Figure 3), (4) shoulder mobility (SM) (Figure 4), (5) active straight leg raise (ASLR) (Figure 5), (6) trunk stability push up (TS) (Figure 6), and (7) rotary stability (RS) (Figure 7). In accordance with the criteria proposed in literature, a participant was given 3 points for a correct performance of a given trial; 2 points were granted for a trial performed with compensation, 1 point – if the participant was unable to correctly execute a given movement pattern, and 0 – when the participant experienced pain during the trial. Each of the 7 trials was performed 3 times. The best score out of the 3 attempts was used for analysis. In addition, each participant performed 3 provocation trials: SM, TS, and RS, which were analysed in combination with particular fundamental movement patterns. The additional trials were performed after the test proper. The participants were not given points for successfully executing the provocation trials. Rather, the provocation trials were conducted to observe the pain response; if pain did occur, the participant was given 0 points. All provocation trials were conducted according to the methodology proposed by Cook et al. [8, 9]. In the case of asymmetric trials (i.e. those in which points are given separately for the left and right sides of the body), the lower of the two scores was used for analysis. This applied to most of the patterns, with the exception of the 2 symmetrical trials, i.e. DS and TS [8, 9].

Statistical analysis

1. The following variables were used for statistical analysis:
a. for ranked variables: mean rank, standard deviation for the mean rank, minimums, maximums, and medians;
b. for qualitative variables: sample sizes and percentages.
2. The statistical significance of the differences between the three groups for ranked variables was assessed with the Kruskal-Wallis H test with a precise estimation of probability. If a statistically significant general effect was observed, differences between pairs of groups were assessed with the use of the Mann-Whitney U test with a precise estimation of probability.
3. The statistical significance of the proportion (percentages) between correct and incorrect results was assessed with z-tests for proportions.

Statistical significance was assumed at $p < 0.05$ for all assessments.

Results

Each participant obtained from 12 to 20 points in total in the FMS test. The mean numbers of points amounted to 16.53 ± 1.77. Juniors achieved the lowest result, with the mean score of 15.27 ± 1.33 points. Both SF and SL groups received better mean scores than juniors in the test (by 17.53 and 16.80 po-

Figure 1. Deep squat trial

Figure 2. Hurdle step trial

Figure 3. In-line lunge trial

Figure 4. Shoulder mobility trial

Figure 5. Active straight leg raise trial

Figure 6. Trunk stability push up trial

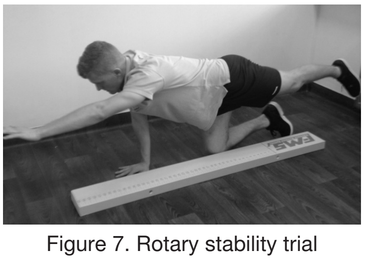

Figure 7. Rotary stability trial

Table 2. Results of the FMS test

	Group	Mean	*SD*	Min	Max	Median
DS	J	2.27	0.46	2	3	2
	SL	2.47	0.52	2	3	2
	SF	2.13	0.35	2	3	2
HS	J	2.00	0.53	1	3	2
	SL	2.33	0.49	2	3	2
	SF	2.20	0.41	2	3	2
IL	J	2.80	0.41	2	3	3
	SL	2.93	0.26	2	3	2
	SF	2.73	0.46	2	3	3
SM	J	2.13	0.74	1	3	2
	SL	2.53	0.64	1	3	3
	SF	2.47	0.52	2	3	2
ASLR	J	2.00	0.53	1	3	2
	SL	2.33	0.49	2	3	2
	SF	2.6	0.51	2	3	3
TS	J	2.13	0.52	1	3	2
	SL	2.87	0.35	2	3	3
	SF	2.67	0.49	2	3	3
RS	J	1.93	0.26	1	2	2
	SL	2.07	0.26	2	3	2
	SF	2.00	0.00	2	2	2
Total score	J	15.27	1.33	12	17	15
	SL	17.53	1.81	14	20	18
	SF	16.80	1.37	15	20	17

DS – deep squat, HS – hurdle step, IL – in-line lunge, SM – shoulder mobility, ASLR – active straight leg raise, TS – trunk stability push up, RS – rotary stability, J – juniors, SL – seniors from the Silesia-Opole 3rd league, SF – seniors from the futsal Extra Class league

ints, respectively). In 5 of the 7 trials (HS, SM, ASLR, RS, and TS), juniors obtained the lowest mean scores. In the 2 other trials (DS and IL), SF players achieved the lowest mean scores (Table 2).

The statistical analysis indicated the significance of the differences in the total FMS score between the groups (p = 0.001). Detailed analysis showed that the mean FMS score in both the SL and SF groups was statistically significantly higher than among juniors (statistical significance amounted to p = 0.019 and p = 0.006, respectively). The differences in the obtained scores between the SL and SF groups were found to be statistically insignificant. Furthermore, in the TS test, the SL and SF groups achieved statistically significantly higher scores than juniors (p = 0.001 in both cases), with no statistically significant differences between SL and SF (Table 3).

The distribution of correct results (3 points obtained during a trial) and incorrect results (2, 1, or 0 points) in each trial and in each group of soccer players was also analysed (Table 4).

In the DS trial, SL players obtained a correct result statistically significantly more often than SF players. In the ASLR trial, juniors achieved a correct result less often than SF players. In the TS trial, juniors got a correct result less often than both SF and SL groups (Table 5).

Table 3. Statistical analysis of the differences in FMS scores between the groups

	chi^2 (2)	Precise p	Differences between groups (Mann-Whithney U p)		
			J-SL	J-SF	SL-SF
DS	4.02	0.162			
HS	3.24	0.208			
IL	2.08	0.488			
SM	2.86	0.242			
ASLR	8.43	0.013			
TS	14.51	< 0.001	0.001*	0.001*	0.390
RS	2.93	0.682			
Total score	13.01	0.001	0.019*	0.006*	0.165

DS – deep squat, HS – hurdle step, IL – in-line lunge, SM – shoulder mobility, ASLR – active straight leg raise, TS – trunk stability push up, RS – rotary stability, J – juniors, SL – seniors from the Silesia-Opole 3rd league, SF – seniors from the futsal Extra Class league
* Statistical significance of $p < 0.05$

Table 4. Percentage distribution of correct (3 points) and incorrect (0, 1, or 2 points) results obtained in the FMS test

Variable	Group	Correct result (%)	Incorrect result (%)
DS	J	26.67	73.33
	SL	46.67	53.33
	SF	13.33	86.67
HS	J	13.33	86.67
	SL	33.33	66.67
	SF	20.00	80.00
IL	J	80.00	20.00
	SL	93.33	6.67
	SF	73.33	26.67
SM	J	33.33	66.67
	SL	60.00	40.00
	SF	46.67	53.33
ASLR	J	13.33	86.67
	SL	33.33	66.67
	SF	60.00	40.00
TS	J	20.00	80.00
	SL	86.67	13.33
	SF	66.67	33.33
RS	J	0.00	100.00
	SL	6.67	93.33
	SF	0.00	100.00

DS – deep squat, HS – hurdle step, IL – in-line lunge, SM – shoulder mobility, ASLR – active straight leg raise, TS – trunk stability push up, RS – rotary stability, J – juniors, SL – seniors from the Silesia-Opole 3rd league, SF – seniors from the futsal Extra Class league

Table 5. Statistical analysis of differences in the percentage distribution of correct and incorrect results in the FMS test among juniors, seniors playing on grass, and seniors playing indoors

Dependent variable	Differences between groups					
	J-SL		J-SF		SL-SF	
	z	*p*	*z*	*p*	*z*	*p*
DS	1.1	0.256	0.9	0.361	2.0	0.046*
HS	1.3	0.195	0.5	0.624	0.8	0.409
IL	1.1	0.283	0.4	0.466	1.5	0.142
SM	1.5	0.143	0.7	0.456	0.7	0.464
ASLR	1.3	0.195	2.7	0.008*	1.5	0.143
TS	3.7	< 0.001*	2.6	0.010*	1.3	0.195
RS	1.0	0.309	–	–	1.0	0.309

DS – deep squat, HS – hurdle step, IL – in-line lunge, SM – shoulder mobility, ASLR – active straight leg raise, TS – trunk stability push up, RS – rotary stability, J – juniors, SL – seniors from the Silesia-Opole 3rd league, SF – seniors from the futsal Extra Class league
* Statistical significance of $p < 0.05$

Discussion

The study participants displayed differences in their functional status depending on age and the training surface. Seniors obtained better results in the FMS test than juniors. Furthermore, participants who played on grass performed better than those who played indoors.

Individual functional assessment is part of motor preparation and a starting point for the training of athletes in both individual and team disciplines on all levels of skill, including professional soccer teams [2, 5]. Even the sum of points obtained in the FMS test alone provides information about a given player's basic motor skills [8, 9]. Schneiders et al. conducted the FMS test among active young men, who obtained a mean score of 15.8 points [12]. The juniors from the Beskids Sports Association club, Rekord Bielsko-Biała, who participated in the presented study achieved a similar mean score in the FMS test, i.e. 15.27 points. In turn, seniors got better mean scores: 17.53 points among SL players and 16.80 points among SF players. The lower scores obtained by juniors may stem from the incomplete development in such key areas as bone growth, coordination skills, or muscle strength, which results in a decreased stability of the joints [10, 12]. These factors not only make it difficult to perform the assessed movement patterns without compensation, but also greatly increase the risk of overload and injury [1, 5].

The study showed that, as expected, seniors displayed better basic motor skills than juniors. This may be due to the appropriately directed long-term training that shaped not only the senior's motor and technical skills, but also prevention, including stability training or symmetrical strengthening of the motor system. Kiesel et al. obtained similar results. In their study, professional soccer players achieved above-average scores in the FMS test ($\bar{x}$ = 16.9 points) [2]. As with this study, Adamczyk et al. also observed differences in the functional status of players with different levels of skill. They noted a proportional correlation between the FMS score and sports class [13].

The FMS test allows to assess the risk of injury [2, 5, 6]. Research shows that the FMS score of 14 points or less considerably increases the risk of injury in the future (even by 50%). Among the participants of the study, 4 were unable to exceed 14 points. Out of these 4, as many as 3 were juniors (one obtained 12 points and two achieved 14 points); the fourth player belonged to the SL group (14 points). The results indicate that in the case of junior players, an additional, detailed analysis of all trials should be performed. Juniors should also take part in specialized functional training that would aim to reduce the risk of injury by improving the players' mobility, stability, and neuromuscular control, and by correcting their fundamental movement patterns.

One of the aims of the present study was to determine the most common movement deficits in soccer players. Among the study participants, the lowest FMS scores and the most common deficits in basic motor skills were observed in the TS ($\bar{x}$ = 2.0), HS ($\bar{x}$ = 2.18), and ASLR ($\bar{x}$ = 2.31) trials.

Juniors obtained the lowest mean scores in these three trials (1.93, 2.13, and 2.00 points, respectively), which indicates that the youngest group have insufficient strength and coordination of the core muscles of the trunk and the muscles of the pelvic girdle. However, Grabara et al. note that soccer training is more effective at shaping certain motor skills in children, especially the flexibility and mobility of spine joints, as compared with traditional physical education curricula [14]. These authors' study suggests that FMS scores could be lower among peers (i.e. children born in 2012) who do not train.

Juniors obtained the lowest score in the RS trial; this result was statistically significantly lower than in both senior groups. Donatelli states that the better the stability muscles of the trunk are synchronized with the muscles of joints responsible for movement, the greater the chances are for good performance at sports and the lower the risk of injury [15]. Research has confirmed the effectiveness of stability training not only among athletes, but among particular professional groups as well. For instance, Peate et al. assessed the functional status of fire fighters with the FMS test, after which the fire fighters underwent regular stability training. After two months, the group performed better in the follow-up test and, more importantly, the number of injury-related absences from work decreased by 62% and the number of accidents was reduced by 42% [16].

Actions performed while standing on one foot are of particular importance for soccer players, and this asymmetric position dominates during matches. Every pass, shot, block, and jump requires the activation of muscles under asymmetric conditions [17]. This ability is verified in the HS trial of the FMS test. The HS trial proved to be very difficult for the studied players. Each group displayed deficits in neuromuscular coordination of the pelvic girdle, decreased mobility, and decreased stability of the entire kinematic chain of the lower limb. As compared with the mean FMS scores among the general population (2.23) [12] and professional soccer players (2.60) [18], the score obtained by the study participants was below average (2.18). The observations made by the authors of this study indicate that the most common dysfunction that appears during the FMS test is the non-axial alignment of the stepping leg. In a vast majority of cases, the testees showed an excessive external rotation in the hip joint when stepping over the hurdle.

The active lifting of an extended lower leg is another motor task during which the study participants showed a considerable deficit, especially the group who played on grass (juniors: $\bar{x}$ = 2.00 points; SL: $\bar{x}$ = 2.33 points). The SF group obtained a higher mean score in the ASLR trial ($\bar{x}$ = 2.6 points). Deficits in the active raising of an extended lower limb may often be related to excessive tension and functional shortening of the muscles of the hip and shin, which is common among soccer players. Furthermore, this group of muscles is subject to injury among soccer players especially frequently [15]. There are many reasons why injuries of the biceps femoris, semitendinosus, and semimembranosus muscles are so common. Apart from Donatelli's statement that post-exercise muscle damage most often concerns two-jointed muscles and muscles with a dominance of type II fibres, these reasons include an incorrect activation of the pelvic girdle muscles during motion, inappropriate warm-up, insufficient flexibility, and failure to strengthen the muscles during eccentric contraction [1, 15, 19]. Eccentric contraction is extremely important, as appropriate eccentric strength of the hip and shin muscles allows for the compensation of load when walking or running and for many functional movements during play. As Dvorak notes, it is crucial to introduce plyometric training, primarily in order to shorten the period required for the compensation, i.e. the period between the efficient contraction of the muscle and the initiation of the concentric contraction [19].

Factors that increase the risk of injury in the muscles of the hip and shin also include unbalanced muscle strength, which can be assessed indirectly through the FMS test in the DS and IL trials. Unbalanced muscle strength results from functional changes which in turn are believed to stem from disruptions to the distribution of tension between agonist and antagonist muscles [3, 15]. Many coaches do not take into account the rule of a balanced development of antagonist groups of muscles, which often leads to over-strengthening of the quadriceps femoris muscle, disregarding or underestimating the development of the antagonist muscles, i.e. the hip and shin group and the gluteus maximus muscle.

The result of the DS test indicated considerable deficits in the mobility and stability of the entire kinematic chain of the lower limb and the lumbar section of the spine. The group who played soccer indoors obtained the mean score of only 2.13 points in this trial. Higher results were observed among the two other groups: 2.26 points among juniors and 2.47 points in the SL group. This disproportion may be caused by the specificity of indoor soccer, which requires the use of slightly different movement patterns, which, furthermore, are repeated more frequently indoors than on a larger pitch covered with grass. Indoor soccer forces the players to perform rapid, dynamic movements, frequently change the direction they are moving in, and assume specific, often unnatural positions. This may lead to incorrect movement strategies and, as a consequence, to weaker stability and thus to a structural damage to the motor system both above and below the pelvic girdle. Studies have also shown that playing on a hard floor increases the level of tissue stress markers [11]. Epidemiological research confirms the high rate of injuries in the knee and ankle joints among futsal players, frequently reporting cases of tendinopathy of the Achilles tendon and the ligament of the patella [20].

In sum, seniors displayed a better functional status than juniors. In most trials, the SL group obtained better scores than the other two groups, with the exception of the ASLR trial, in which the SF group achieved a higher mean score than the SL group, who played on grass. The results observed in the study indicate that during the motor preparation of athletes, coaches and physical therapists should pay greater attention to the achievement of appropriate muscle elasticity, to functional exercises that focus on strengthening the pelvic girdle muscles, to the improvement of central stability, and to the usage of varied surfaces for each part of training.

Limitations

It should be emphasized that the assessment of basic motor skills with the use of the FMS test only allows for a subjective interpretation. In order to maximize the reliability of the study, each participant was supervised by the same person during the trials. The research assessed the effect of the surface on the relevant parameters. However, the group of participants who trained indoors only included seniors. A higher comparative reliability could be achieved by including young futsal league players.

Conclusions

1. The mean total FMS score obtained by the participants of the study does not indicate an increased risk of injury. On the other hand, individual scores suggest that 13% of the participants (four players) are characterized by an increased risk of injury.

2. Seniors (both the group who played on grass and those who played indoors) showed a better functional status that juniors.

3. The most common deficits in basic motor skills among the study participants were a low stability and mobility within the hip-pelvic-lumbar system and a muscular imbalance within the kinematic chain of the lower limb.

4. The soccer players who play on grass display a better functional status than the indoor players. This correlation was observed in all trials except for ASLR.

Conflict of interest statement:
Authors state no conflict of interest.

References

1. Kirkendall DT, Junge A, Dvorak J. Prevention of football injuries. Asian J Sports Med. 2010;1(2):81–92; doi: 10.5812/asjsm.34869.
2. Kiesel K, Plisky PJ, Voight ML. Can serious injury in professional football be predicted by a preseason Functional Movement Screen? N Am J Sports Phys Ther. 2007;2(3):147–158.
3. Rzepka R, Grzybczak T, Więcek R. Functional workout and the possibilities of its application in football training [in Polish]. In: Stuła A (ed.), Theoretical and practical aspects of the modern football play [in Polish]. Opole: Politechnika Opolska, Akademicki Inkubator Przedsiębiorczości; 2009; 209–244.
4. Zając A, Wilk M, Poprzęcki S, Bacik B, Rzepka R, Mikołajec K, et al. Contemporary muscle strength workout [in Polish]. Katowice: AWF; 2010.
5. Garrison M, Westrick R, Johnson MR, Benenson J. Association between the Functional Movement Screen and injury development in college athletes. Int J Sports Phys Ther. 2015;10(1):21–28.
6. Letafatkar A, Hadadnezhad M, Shojaedin S, Mohamadi E. Relationship between functional movement screening score and history of injury. Int J Sports Phys Ther. 2014;9(1):21–27.
7. Minick K, Kiesel KB, Burton L, Taylor A, Pilsky P, Butler RJ. Interrater reliability of the functional movement screen. J Strength Cond Res. 2010;24(2):479–486; doi: 10.1519/JSC.0b013e3181c09c04.
8. Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function – Part 1. N Am J Sports Phys Ther. 2006;1(2):62–72.
9. Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function – Part 2. N Am J Sports Phys Ther. 2006;1(3):132–139.
10. Woynarowska B. Selected issues children and youth sport [in Polish]. In: Jegier A, Nazar K, Dziak A (eds.), Sports medicine [in Polish]. Warszawa: PTMS; 2005; 175–235.
11. Milanez VF, Ramos SP, Okuno NM, Boullosa DA, Nakamura FY. Evidence of a non-linear dose-response relationship between training load and stress markers in elite female futsal players. J Sports Sci Med. 2014;13(1):22–29.
12. Schneiders AG, Davidsson A, Hörman E, Sullivan SJ. Functional Movement Screen™ normative values in a young, active population. Int J Sports Phys Ther. 2011;6(2):75–82.
13. Adamczyk J, Pepłowski M, Boguszewski D, Białoszewski D. Functional evaluation of competitors practising weightlifting with using Functional Movement Screen test. Med Sport. 2012;28(4):267–276; doi: 10.5604/1232406X.1030820.
14. Grabara M, Kołodziej G, Wójcik M. Spine flexibility and the prevalence of contractures of selected postural muscle groups in junior male football players. Phys Edu Sport. 2010;54(1):27–36.
15. Donatelli RA. Rehabilitation in sport [in Polish]. Wrocław: Elsevier Urban & Partner; 2011.
16. Peate WF, Bates G, Lunda K, Francis S, Bellamy K. Core strength: a new model for injury prediction and prevention. J Occup Med Toxicol. 2007;2(3):1–9; doi: 10.1186/1745-6673-2-3.
17. Pedersen S, Magnussen R, Kuffel E, Seiler S. Sling exercise training improves balance, kicking velocity and torso stabilization strength in elite soccer players. Med Sci Sports Exerc. 2006;38(5):243.
18. Szymczyk D, Oleksy Ł, Wróbel K, Opaliński G. Functional assessment of football players using FMS (Functional Movement Screen) [in Polish]. Zamojskie Studia i Materiały. Seria: Fizjoterapia. 2010;12(1):55–68.
19. Dvorak J, Junge A, Grimm K (eds.). F-MARC Football Medicine Manual, 2nd edition. Zurych: FIFA; 2009.
20. Abate M, Schiavone C, Salini V. High prevalence of patellar and Achilles tendinopathies in futsal athletes. J Sports Sci Med. 2012;11(1):180–181.

Received: 01.02.2017
Revised: 24.02.2017
Accepted: 25.02.2017

Address for correspondence
Stanisław Gadziński
Wydział Rehabilitacji Ruchowej
Akademia Wychowania Fizycznego
al. Jana Pawła II 78
31-571 Kraków, Poland
e-mail: Gadzinskistanislaw@gmail.com