ORIGINAL ARTICLE

TRENDS in
Sport Sciences
2014; **3**(21): 145-151.
ISSN 2299-9590

Fundamental movement patterns and potential risk of injuries in 1st and 2nd division Polish handball players

ROBERT SŁODOWNIK[1], ANNA OGONOWSKA-SŁODOWNIK[2],
NATALIA MORGULEC-ADAMOWICZ[2], PAWEŁ TARGOSIŃSKI[3]

Introduction. **The Functional Movement Screen™ (FMS™) is one of modern functional assessment tools used, for example, for qualitative evaluation of fundamental movement patterns and potential injury risks.** **Aim of Study.** **The purpose of this study was to assess the performance of handball players with the use of Functional Movement Screen™ (FMS™) in consideration of their competitive level, position on the court and symmetry of movement patterns.** **Material and Methods.** **Thirty 1st and 2nd division handball players participated in the study. All subjects were healthy men aged 23.23 ± 3.59 years, with body height of 184 ± 5.6 cm and body mass of 86.37 ± 8.61 kg. The players performed seven tests from the Functional Movement Screen™. Statistical analysis was made using the SPSS Statistics 21.0 software package. The level of statistical significance was set at $p \leq 0.05$.** **Results.** **No significant differences in handball players' general characteristics were found between both divisions. Student's t-test showed no significant differences between the two groups in total FMS™ score. Statistically significant differences were noted in the Shoulder Mobility (SM) test ($U = 308.5$; $p = 0.014$) between the right and the left upper extremity.** **Conclusions.** **The study revealed no statistically significant differences in FMS™ test scores between the 1st and 2nd division handball players as well as between players in different playing positions on the court. Also no higher risk of injury was shown among the 1st and 2nd division handball players. The study confirmed, however, characteristic adaptation of the throwing arm typical for throwing sports in the form of glenohumeral internal rotation deficit.**

KEYWORDS: handball, fundamental movement patterns, Functional Movement Screen™, injury risk.

Received: 25 August 2014
Accepted: 29 August 2014

Corresponding author: natalia.morgulec@awf.edu.pl

[1] *SpOrtopedic, Warszawa, Poland*

[2] *The Józef Piłsudski University of Physical Education in Warsaw, Department of Adapted Physical Activity, Warszawa, Poland*

[3] *The Józef Piłsudski University of Physical Education in Warsaw, Department of Kinesiotherapy, Warszawa, Poland*

What is already known on this topic?
Handball is one of the Olympic team sports involving the highest risk of injuries. The evaluation of players' fundamental movement patters using the Functional Movement Screen™ is a quality method of injury risk assessment, which has not been yet applied in handball research.

Introduction

Motor patterns are the basis of human movements. Their incorrect execution may lead to pain and injuries. Additionally, it can also be a cause and consequence of malfunctions of the human body systems responsible for the quantity and quality of movement. Identification of irregularities in the performance of movement patterns and the sources of such irregularities are therefore very important in sport.

According to Gallahue, Ozmun and Goodway [1] movement patterns are series of consecutive, interconnected movements of particular body parts in space. They can be classified in terms of movement volume (gross and fine motor skills), time (single, repeated or constant) application in a given environment (open and closed motor skills) and purpose (functional motor skills, including balancing, locomotor and manipulative). Gallahue, Ozmun and Goodway also identify movement patterns as executions of fundamental locomotor, manipulative and balancing movements being combinations of movement patterns of two or more body parts (e.g. running, throwing, turning). A combination of fundamental movement patterns is the basis of performance of specific motor tasks in a given sport, while perfecting movement patterns greatly enhances the improvement of sport-specific skills. Irregularities in the biomechanics of the locomotor system and improper fundamental movement patterns can have a negative impact on sport results and increase the risk of injuries in athletes [2, 3].

The assessment of motor skills in sport is still dominated by tests measuring particular motor skills separately, i.e. strength, force, endurance, balance, spatio-temporal coordination, etc. Such measurements are then compared with reference values or athletes' earlier assessment results. Examples of tests assessing motor skills of handball players at different stages of their training and competitive career do confirm such dominance [4, 5]. Although these separate measurements are important in evaluation of the training process, they do not permit a comprehensive assessment of a player's fundamental movement patterns developed in motor training and constituting the basis for the performance of correct and ergonomic movements specific for a given sport [2, 3].

Functional tests before the preparatory or pre-competitive training stages should be integral parts of the training process and they should be used to identify potential injury hazards including injuries of the musculoskeletal system [6]. They can also be helpful in identifying functional deficits in the fundamental movement patterns in a given sport. Researchers have been seeking the most optimal assessment tool for identification of potential injury risks [7]. The present research is of particular importance in handball, which is an Olympic sport with one of the highest risks of injuries.

One of functional testing tools used in sport sciences is the Functional Movement Screen™ (FMS™). It is a battery of tests developed by an American physical therapist Gray Cook and athletic coach Lee Burton. The FMS™ has been used for comprehensive qualitative assessment of fundamental movement patterns and potential injury risks. Its main advantages include quick and easy performance, non-invasiveness and low price. The FMS™ consists of 7 tests, including 5 asymmetric tests assessing the performance of the right and the left body side/extremity, respectively. Each test is scored from 0 to 3 points, with a maximum total score of 21 points. Studies show that a score of 14 points and below indicates a four to eleven-time higher risk of injuries [8-10]. In handball which involves a high incidence of injuries, the application of the FMS™ can be very effective. Its results can indicate ways in which the percentage of non-contact and overload injuries can be reduced. It can be assumed that the competitive level, playing position and asymmetry of movements of handball players affect the risk of injuries that can be measured by the FMS™, a tool that has never been used in studies on handball before.

Aim of Study

The purpose of this study was to assess the performance of handball players with the use of Functional Movement Screen™ (FMS™) in consideration of their competitive level, position on the court and symmetry of movement patterns.

Material and Methods

Thirty 1st and 2nd division handball players participated in the study. All subjects were healthy men aged 23.23 ± 3.59 years, with body height of 184 ± 5.6 cm and body mass 86.37 ± 8.61 kg. The subjects performed 7 tests (5 asymmetric, 2 symmetric) from the Functional Movement Screen™ with use of FMS Kit™ containing a 5 x 15 x 150 cm measuring device, 2 hurdles, a measuring stick and the FMS Score Sheet. Asymmetric test were: Hurdle Step, In-line Lunge, Shoulder Mobility, Active Straight Leg Raise and Rotary Stability. The total score of those tests consisted of component scores of tests performed with the right and the left body side, taking the lower score of the two as the final score for this particular test [2, 3]. In the two other, symmetric tests, i.e. Deep Squat and Trunk Stability Push-up no component scores were recorded. During the Shoulder Mobility, Trunk Stability Push-Up and Rotary Stability tests the subjects also performed additional tests aimed at identification of potential dysfunctions in the examined body areas. Each test was scored from 0 to 3 points. The appearance of pain, regardless of performance quality of tests or additional tests (i.e. a positive result of an additional test) resulted in a 0 score for any given test.

The study was carried out between June 4 and June 15, 2013, following the competitive seasons of the 1st and 2nd Divisions of the Polish handball league. The subjects undertook the tests in their training outfits, before the training sessions. The performance of each test was demonstrated before the examination. The players had been informed about the purpose of the tests and they had given their willful consent to participate.

The statistical analysis was made with the use of the SPSS Statistics 21.0 software package. Descriptive statistics were used for all variables (general characteristics and test results). The distribution of values of dependent variables in the 1st and 2nd Division players was checked with the Shapiro-Wilk test. Student's t-test for independent samples was used to measure the significance of differences in players' general characteristics and total scores of the FMS™ tests. The equality of variances was measured with Levene's test. The differences in general characteristics and total FMS™ test scores between four groups of players divided according to their playing positions were determined with the Kruskal-Wallis test. When the differences were statistically non-significant, the Mann-Whitney test was used to assess differences between the playing positions (Goalkeepers – G, Back players – B, Wing players – W, Pivots – P). Pearson's coefficients of correlation (r) were calculated for the study sample (n = 30), between the players' total FMS™ test scores, age, training experience, number of training hours per week and anthropometric indices (body height, body mass, body mass index). The comparison between the results of the asymmetric tests of the left and the right body side/extremities of handball players was made using the Mann-Whitney test. The level of statistical significance was set at $p \leq 0.05$.

Results

Table 1 shows the general characteristics of the 1st and 2nd Division handball players under study. Student's t-test for independent samples did not reveal any significant differences between the 1st and 2nd Division players in terms of their age, body height, body mass, BMI, training experience and the number of training hours per week (Table 1). The players were also divided into four groups according to their playing positions: Goalkeepers – G, Back players – B, Wing players – W and Pivots – P. The players' general characteristics (age, body height, body mass, BMI, experience and the number of training hours per week) are presented in Table 2.

The results of the non-parametric Kruskal-Wallis test did not show any significant differences between players in different playing positions on the court (G, B, W, P), in their general characteristics (apart from body mass – $\chi^2 = 9.01$; $p = 0.02$ and BMI – $\chi^2 = 8.54$; $p = 0.03$), and in the total FMS™ test scores. The *post hoc* analysis of body mass and BMI using the Mann-Whitney test revealed significant differences in body mass between G and B ($U = 10.5$; $p = 0.042$) and W and P ($U = 7$; $p = 0.015$); and in BMI between G and B ($U = 4$; $p = 0.005$) and B and P ($U = 9$; $p = 0.028$).

Table 1. General characteristics of players from the 1st and 2nd Divisions of the Polish handball league

	1st Division (n = 15)			2nd Division (n = 15)			t	p
	$\bar{x}$	SD	Min. – Max	$\bar{x}$	SD	Min. – Max		
Age (years)	24.1	3.4	21-31	22.3	3.7	17-31	1.396	0.174
Body height (cm)	182.3	5.7	175-196	185.9	5.1	178-196	–1.817	0.080
Body mass (kg)	85.1	9.6	69-102	87.6	7.6	73-105	–0.779	0.442
BMI	25.6	2.2	23-30	25.3	1.8	22-29	0.318	0.752
Training experience (years)	12.3	3.9	6-23	9.7	4.3	3-18	1.763	0.089
Number of training hours per week	5.6	1.3	5-8	5.3	1.2	5-8	0.580	0.567

Table 2. General characteristics of handball players in different playing positions

	Playing position	$\overline{x}$	SD	Min. – Max
Age (years)	G (n = 7)	24.6	5.2	17-31
	B (n = 8)	23	3.4	17-27
	W (n = 8)	22	1.8	21-26
	P (n = 7)	23.6	3.8	17-28
Body height (cm)	G (n = 7)	184.3	3.8	180-190
	B (n = 8)	184.2	3.9	176-189
	W (n = 8)	181	5.1	175-189
	P (n = 7)	187.4	8.1	176-196
Body mass (kg)	G (n = 7)	89.6	6.4	80-100
	B (n = 8)	82.1	6.9	72-90
	W (n = 8)	81.6	7.1	69-92
	P (n = 7)	93.4	8.8	84-105
BMI	G (n = 7)	26.3	1.2	24-28
	B (n = 8)	24.2	1.4	22-26
	W (n = 8)	24.9	2.3	23-29
	P (n = 7)	26.6	2.2	24-30
Training experience (years)	G (n = 7)	14	5.8	4-23
	B (n = 8)	10.7	3.4	4-15
	W (n = 8)	10.2	3.2	6-15
	P (n = 7)	9.1	3.7	3-14
Number of training hours per week	G (n = 7)	5.6	1.5	5-8
	B (n = 8)	4.9	0.7	5-6
	W (n = 8)	5.6	1.3	5-8
	P (n = 7)	5.8	1.3	5-8

Goalkeeper (G), Center Backcourt (CB), Wingman (W), Pivot (P)

Figures 1 and 2 show the results of all the FMS™ tests attained by the 1st and 2nd Divisions handball. The Student's t-test for independent variables revealed no significant differences between the players from the two divisions in their total test scores (t = 0.79; p = 0.93). The mean result of players from the 1st Division was 15.5 ± 1.9, and of players from the 2nd Division amounted to 15.4 ± 2.6 points. The values of Pearson's coefficients of correlation (r) for the handball players' total FMS™ test score, age, training experience, number of training hours per week and anthropometric indices (body weight, body mass, BMI) were statistically non-significant.

The analysis of results of the FMS™ asymmetric tests performed with the right and the left side of the body by the handball players (Mann-Whitney test) revealed statistically significant differences between the right and the left side in the Shoulder Mobility test (Table 3).

Discussion

The correct execution of fundamental movement patterns is necessary for development of particular motor skills

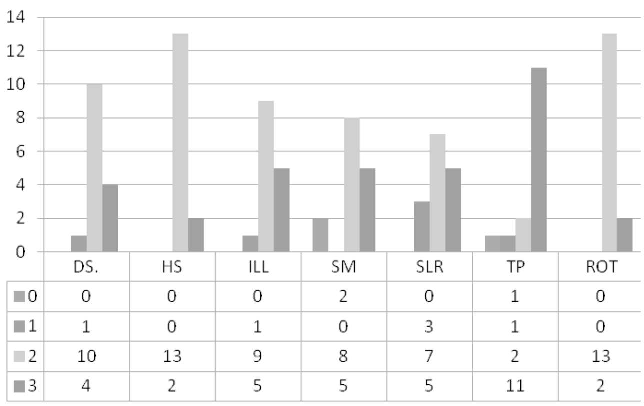

Figure 1. Frequency of scores of particular FMS™ component tests in 1st Division handball players

DS – Deep Squat, HS – Hurdle Step, ILL – In-Line Lunge, SM – Shoulder Mobility, TP – Trunk Stability Push-Up, ROT – Rotary Stability

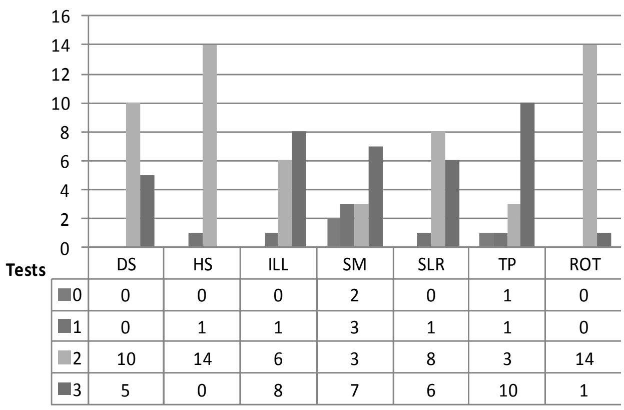

Figure 2. Frequency of scores of particular FMS™ component tests in 2nd Division handball players

DS – Deep Squat, HS – Hurdle Step, ILL – In-Line Lunge, SM – Shoulder Mobility, TP – Trunk Stability Push-Up, ROT – Rotary Stability

Table 3. Comparison of handball players' test results of the right and the left body side/extremity in the asymmetric FMS™ Test Kit tests

Test	Body side/lower extremity/ upper extremity	$\bar{x}$	SD	Med.	U	p
Hurdle Step	R	2.1	0.4	2	435.5	0.700
	L	2.0	0.3	2		
In-Line Lunge	R	2.4	0.6	2	435.5	0.807
	L	2.4	0.6	2		
Shoulder Mobility	R	2.7	0.7	3	308.5	0.014*
	L	2.4	0.7	2		
Active Straight Leg Raise	R	2.34	0.6	2	440.5	0.874
	L	2.3	0.6	2		
Rotary Stability	R	2.1	0.3	2	450.0	1.000
	L	2.1	0.3	2		

* statistically significant difference between R and L at $p \leq 0.05$
R – right side/extremity; L – left side/extremity

and, therefore, for attaining good sports results. The Functional Movement Screen™ is an useful assessment tool filling the gap between screening tests and general motor skills assessment tests in any given sport [2, 3].
The performed tests did not show any statistically significant differences between the total FMS™ test score and component scores attained by the 1st and 2nd Division players. This could have been caused by the relatively low differences in their sports level between players of both divisions. The analysis also revealed no statistically significant differences between players in their general characteristics. In a study of handball players from a top Spanish club of international renown and from an amateur 2nd Spanish division club by Gorostiaga et al. [4] significantly better results of anthropometric measurements (body mass, BMI, fat free mass), motor tests (strength, muscle force of the arms and the legs) and handball-specific tests, e.g. throwing velocity, were attained by the players from the top professional club. Future studies on larger samples with more diverse sports levels may be more accurate for determining the impact of the sports level and anthropometric characteristics on the quality of execution of fundamental movement patterns and on potential injury risks.
It must be noted that the mean results of the FMS™ tests obtained by the studied handball players from both divisions aged 23.23 ± 3.59 years, correspond to the mean total FMS™ test score for athletes aged 19-37 years, i.e. 15.8 ± 1.8 [11]. Schneiders et al. [11] also observed that 31% of their subjects scored below 14 points in the total FMS™ test result, whereas this result was attained by 40% of examined handball players. Considering the age range reference values for healthy but physically non-active individuals aged 20-39 years whose mean FMS™ test score was 14.79 ± 2.76, the handball players' scores were much better. These results show a huge advantage of athletes in performing the fundamental movement patterns, which confirms the common conviction that athletes are much better fit that non-active individuals.
The FMS™ consists mostly of asymmetric tests. Statistically significant differences between the test results for the right and the left upper extremity were found in the Shoulder Mobility test (U = 308.5; p = 0.014). In the test lower scores were attained when the left arm was in maximal external rotation and the right arm in maximal internal rotation. All players who displayed asymmetry in their Shoulder Mobility test were right-handed. The asymmetry observed in the Shoulder Mobility test could be caused by the limitation of internal rotation of the throwing arm. Almeida et al. [12] in their study of handball players indicated a characteristic adaptation of the throwing arm called Glenohumeral Internal Rotation Deficit (GIRD). Their observations are confirmed by the results of the present study and may explain the significant differences in the Shoulder Mobility test results between the handball players of the 1st and 2nd divisions.
According to Kiesel et al. [8], Chorb et al. [9] and Kiesel et al. [10] the total FMS™ test score at or below 14 points indicates a higher risk of injuries. Kiesel et al. [10] also associated a higher injury risk with revealing additionally at least one asymmetry in the athlete's

fundamental movement patterns. The mean score for the handball players amounted to 15.4 ± 2.3, which can indicate no potential risk of injuries. However, 12 out of 30 players attained the score of 13.17; 83% of players revealed at least one asymmetry in their fundamental movement patterns, and all of these players scored 1 or 0 in at least one of the FMS™ component tests. This is indicative of incorrect test performance, inability to perform a given test or appearance of pain. Among the players who attained a total score above 14 points only 39% displayed an asymmetry, two scored 1 point in at least one component test, and none experienced pains during the test execution. This can be indicative of training deficits in the performance of fundamental movement patterns, since following appropriately selected progressive, corrective exercise program the total FMS™ test score was higher and the number of asymmetries was lower [13].

The noted lack of differences between the FMS™ scores of handball players according to their court position point to their similar levels of fundamental movement patterns. On the other hand, Kiesel et al. [13] and Kawałek and Garsztka [14] claim that the player's position on the court has an impact on movement limitations, symmetry of muscle tension and the quality of execution of fundamental movement patterns. The lack of differences may indirectly indicate a similar risk of injuries. Pieper and Muschol [15] showed that among a group of injured handball players, 29-55% were back players, while 23-37% were wing players. The present study using the FMS™ did not confirm such observations. Prospective studies on larger samples with the use of the FMS™ should also involve the history of the injury before and after the tests.

The Functional Movement Screen™ is a tool which is still rarely used in sport studies for assessment of injury risks on the basis of athletes' performance of fundamental movement patterns, for evaluation of training-induced changes, and as an index of sport performance. The present study shows that the FMS™ can be effectively used in handball training in the future.

Conclusions

The study revealed no statistically significant differences in the FMS™ scores between the 1st and 2nd Division handball players as well as between players in different playing positions on the court. Also no higher risk of injury was found among the 1st and 2nd division handball players. The study confirmed, however, the characteristic adaptation of the throwing arm typical for throwing sports in form of the glenohumeral internal rotation deficit.

What this paper adds?

The present study demonstrates a possible application of the Functional Movement Screen™ in handball research for identification of movement asymmetries and higher injury risks as well as differences between handball players of different competitive levels. This is the first handball study based on the use of the FMS™.

References

1. Gallahue D. Understanding motor development: Infants, children, adolescents, adults, 7th edition eBook: David Gallahue, John Ozmun, Jacqueline Goodway: Amazon.co.uk: Kindle Store. 2014.
2. 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.
3. 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.
4. Gorostiaga EM, Granados C, Ibanez J, Izquierdo M. Differences in physical fitness and throwing velocity among elite and amateur male handball players. Int J Sports Med. 2005; 26(3): 225-232.
5. Gorostiaga EM, Granados C, Ibanez J, Gonzalez-Badillo JJ, Izquierdo M. Effects of an entire season on physical fitness changes in elite male handball players. Med Sci Sports Exerc. 2006; 38(2): 357-366.
6. Joy EA, Paisley TS, Price R, Jr., Rassner L, Thiese SM. Optimizing the collegiate preparticipation physical evaluation. Clin J Sport Med. 2004; 14(3): 183-187.
7. Dallinga JM, Benjaminse A, Lemmink KA. Which screening tools can predict injury to the lower extremities in team sports?: a systematic review. Sports Med. 2012; 42(9): 791-815.
8. 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.
9. Chorba RS, Chorba DJ, Bouillon LE, Overmyer CA, Landis JA. Use of a functional movement screening tool to determine injury risk in female collegiate athletes. N Am J Sports Phys Ther. 2010; 5(2): 47-54.

10. Kiesel KB, Butler RJ, Plisky PJ. Prediction of injury by limited and asymmetrical fundamental movement patterns in American football players. J Sport Rehabil. 2014; 23(2): 88-94.
11. Schneiders AG, Davidsson A, Horman E, Sullivan SJ. Functional movement screen normative values in a young, active population. Int J Sports Phys Ther. 2011; 6(2): 75-82.
12. Almeida GP, Silveira PF, Rosseto NP, Barbosa G, Ejnisman B, Cohen M. Glenohumeral range of motion in handball players with and without throwing-related shoulder pain. J Shoulder Elbow Surg. 2013; 22(5): 602-607.
13. Kiesel K, Plisky P, Butler R. Functional movement test scores improve following a standardized off-season intervention program in professional football players. Scand J Med Sci Sports. 2011; 21(2): 287-292.
14. Kawałek K, Garsztka T. An analysis of muscle balance in professional field hockey players. TRENDS in Sport Sciences [Internet]. 2013; 4(20): 181-187.
15. Pieper HG, Muschol M. Sportverletzungen und Überlastungsschäden im Handballsport. 2007; 23(1): 4-10.