THE FUNCTIONAL MOVEMENT SCREEN TEST AS A TOOL FOR FUNCTIONAL EVALUATION OF MOVEMENT PATTERNS IN LONG-DISTANCE RUNNERS

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Keywords: FMS, Functional Movement Screen, injury, injury risk, movement patterns

Abstract:

Aim: The aim of this study was to evaluate the relationship between the results achieved in the Functional Movement Screen test and various aspects of training as well as injury history in long-distance runners.

Basic procedures: The study involved 30 long-distance runners aged 20 to 45 years, training regularly from two to seven days a week and covering a total distance from 10 to 100 km. The subjects completed a questionnaire containing queries about training and past injuries. The Functional Movement Screen test was used to assess the quality of movement patterns.

Results: The mean total score in the FMS test was 16.03 points. Results within the range from 18 to 21 points were achieved by 6 subjects, 3 of the subjects suffering injuries in the past. Results in the range from 14 to 17 points were obtained by 22 subjects, 14 subjects having a history of injury. A score below 14 points was reached by 2 subjects, both of them suffering injuries in the past.

Conclusions: The results of this study indicate that a lower FMS score is associated with a greater number of injuries in the past. Warming up before training is a good way to prevent injury, while stretching after training does not seem reduce the incidence of injury.

Introduction

The basis of injury prevention should be comprehensive evaluation of an athlete founded on physiotherapeutic and motor testing – in particular - the assessment of postural stability and proprioception, strength potential occurring in dynamic conditions and the analysis of basic movement patterns in terms of their correctness [1]. Screening tests are used to assess single and complex movement patterns, strength, balance, agility, range of mobility, symmetry and the effectiveness of movements, which allow to determine the risk of injury. The prevention of injuries is important not only among those professionally practicing a given discipline, but also among amateurs [2].

Playing sports is often associated not only with improvement in health, but also with numerous injuries, overloads or ailments related to, inter alia, an inappropriately selected training plan. The most common problems are related to abnormalities of the locomotor system. At present, this is not just an aspect of competitive sport. Amateur sport has also achieved amazing development, which is why it is often practiced at a very high level, and thus – poses the risk of injury, which not much lower than in competitive sport [3].

One of the most popular forms of physical activity in the world is long-distance running. Its favourable influence on condition and physical fitness causes this discipline to develop very dynamically, while the number of people who decide to join the group of runners increases every year [4]. Despite the overall positive effect of running on the body, it can also cause overloads, especially in the area of the lower limbs. Although runners
are prone to acute injuries, such as a sprained ankle or muscle strain, the majority of problems are caused by repeated minor strains. Based on research, it has been established that 27 to 70% of recreational and professional runners experience such injuries annually [5].

A risk factor for injury occurrence is the lack of adequate control of core stability. A stable trunk is a foundation crucial for long-distance runners, both at competitive and amateur levels. This discipline is a form of physical activity in which the body is subjected to long-term and repeated shocks and loads. Weakening of central stabilisation may lead to a reduction in the efficiency of movement patterns, the occurrence of compensation and, consequently, overload [6]. Therefore, especially in this group of athletes, work on improving or maintaining appropriate quality of basic movement patterns should be a fundamental element of daily training among runners [6,7,8,9].

Functional movement patterns are basic and fundamental movements, requiring a combination of mobility, stability, strength, proper neuromuscular control, and coordination of all involved muscle groups [10, 11]. These movements are the basis for the optimal performance of complex and specific motor tasks, such as running or throwing [12]. Correct interaction between individual elements of the kinematic chain is also required. Any dysfunctions occurring within a given area cause a cascade of changes in adjacent or distant parts of the body [13].

One functional assessment tool commonly used in sport and the rehabilitation of athletes is the Functional Movement Screen (FMS) test. In literature on the subject, there are works on the use of this test among athletes practicing various disciplines, such as football [14, 15, 16], baseball [17] or floorball [18].

Assessment of injury risk among long-distance runners via the FMS test is very limited, while the results of available studies are inconclusive, thus, this research issue was undertaken in our paper.

The aim of this study was to assess the relationship between results obtained in the Functional Movement Screen test and various aspects of training, and the past incidence of injuries in long-distance runners.

**Materials and methods**

**Description of the study group**

The study comprised 30 participants, including 6 women and 24 men aged 20 to 45. The subjects spent 2 to 7 days a week on training, while the number of kilometres covered per week ranged from 10 to 100. A detailed description of the study group is given in Table 1. To qualify the runners, the following inclusion and exclusion criteria were applied.

Inclusion criteria:
- regularity of running training;
- kilometres covered weekly no less than 10;
- age from 20 to 45;
- consent to participate in the research project.

Exclusion criteria:
- irregularity of running training;
- kilometres covered weekly less than 10;
- age below 20 or above 45;
- lack of consent to participate in the research project.

All the subjects received information on the purpose of the study and provided written consent for participation. Each person completed an original interview questionnaire. Instructions regarding the methodology of the Functional Movement Screen test were also provided. Then, the subjects underwent movement pattern assessment using the FMS test. All measurements were performed by one examiner. Before beginning the study, the consent of the Bioethics Committee was obtained for conducting medical experiments (No. 40/KBL/OIL/2015). The tests were registered in the international database of clinical trials – Australian and New Zealand Clinical Trials Registry (ANZCTR). All procedures were carried out in accordance with the 1964 Helsinki Declaration and its subsequent amendments.

**Research tools**

**Functional Movement Screen (FMS) test**

The Functional Movement Screen test was used to assess the subjects. This is a comprehensive test to determine the quality of basic movement patterns that require a combination of stability, mobility, strength and

<table>
<thead>
<tr>
<th>Parameter</th>
<th>( \bar{x} \pm SD )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>33.00 ± 9.82</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>174.40 ± 8.11</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>60.47 ± 9.98</td>
</tr>
<tr>
<td>Weekly running distance (km)</td>
<td>46.00 ± 22.30</td>
</tr>
</tbody>
</table>

\( \bar{x} \) – mean

SD – standard deviation
coordination of all involved muscle groups, as well as proper neuromuscular control. Its aim is to detect individual limitations, asymmetries or dysfunctions that may increase the risk of injury [10, 11].

The FMS consists of 7 motor tasks:
1) deep squat;
2) hurdle step;
3) in-line lunge;
4) shoulder mobility;
5) ASLR – active straight leg raise;
6) trunk stability push-up;
7) rotational stability.

Before attempting the trial, the subject was given information on the purpose and course of the test. Each of the movement patterns was described and presented by the researcher. During the tests, the subject was observed from the frontal and sagittal planes (front, back and side). The runner was assessed on a 4-point scale, in which it was possible to get from 0 to 3 points. The evaluation criteria were as follows: 3 points – meant full execution of the movement with no visible compensation elements. 2 points – were awarded when compensation was observed in the subject. 1 point – was received by a person who was unable to perform a given movement pattern, while 0 points – were obtained by the subject when pain was experienced during the test. In the case of asymmetrical tests, when there was a difference between the left and right sides, the lower score was considered. All tests were repeated several times [10, 11].

The maximum possible score was 21 points. A person who obtained a result within the range of 18-21 points was qualified to the group with a low risk of injury, because the movement patterns presented by them were correct. The range from 14 to 18 points indicated increased risk due to asymmetries and compensations.

Statistical analysis

Statistical analysis was performed the STATISTICA 12.0 PL software. Data were presented in the form of means (X), standard deviation (SD) and percentages. The normality of the distribution of variables was also assessed using the Shapiro-Wilk test. Spearman’s correlation coefficient was used to evaluate correlations between selected variables. Correlations were considered statistically significant if the test probability (p) level was lower than the adopted significance level of α=0.05. Results are presented in the form of tables and figures.

Results

Functional Movement Screen test

Deep squat

In the deep squat test, 12 subjects received 3 points, while 18 runners scored 2 points. None of the study participants received 1 or 0 points (Fig. 1).

Hurdle step

In the hurdle crossing test, 5 subjects received 3 points, while 25 were awarded 2 points. None of the study participants obtained a lower result (Fig. 2).

In-line lunge

For the in-line lunge test, 5 subjects were given 3 points, while the majority (23 participants) obtained 2 points for this task. Furthermore, 2 respondents received 1 point. None of the subjects scored 0 points (Fig. 3).

Shoulder mobility

In the shoulder mobility test, 24 subjects received 3 points, 6 obtained 2 points. None of the study participants obtained a lower result (Fig. 4).
Fig. 1. Profile [%] of the “Deep squat” test

Fig. 2. Profile [%] of the “Hurdle step” test

Fig. 3. Profile [%] of the “In-line lunge” test
The Functional Movement Screen test...

Fig. 4. Profile [%] of the „Shoulder mobility” test

Fig. 5. Profile [%] of the „ASLR” test

Fig. 6. Profile [%] of the „Trunk stability push-up” test
Active straight leg raise (ASLR)

In the ASLR test, 15 subjects obtained both 3 and 2 points. None of the study participants received a lower result (Fig. 5).

Trunk stability push-up

In the trunk stability push-up test, 3 points were obtained by 12 subjects, 2 points were given to 6 participants, while 1 point was received by 12 individuals. None of the participants scored 0 points (Fig. 6).

Rotational stability

All subjects scored 2 points in the rotational stability test (Fig. 7).

FMS test total score

The mean score among the subjects was 16.03 points. People who had not suffered injury in the past received an average of 16.45 points, while for the group with injuries, the average score was 15.79 points. The lowest total result of the FMS test among the subjects was 13 points and was obtained by 2 participants. A total of 14 points was awarded to 5 individuals, while 4 persons obtained 15 points. The majority (7 subjects) obtained a total result of 16 points. Not much less, i.e. 6 subjects received 17 points. A total of 18 points was scored by 4 subjects, while 1 participant received 19 points. Also, 1 person obtained 20 points. None of the participants managed to obtain a higher result (Fig. 8, Tab. 2).

Fig. 7. Profile [%] of the „Rotational stability” test

Fig. 8. Profile [%] of the total score in the FMS test
The Functional Movement Screen test...

The FMS total score and the occurrence of injuries

There were 6 subjects within the range from 18 to 21, half of whom had experienced injury in the past (3 people). The range from 14 to 17 points was obtained by 22 subjects, including 14 who had suffered an injury in the past. A score of less than 14 points was obtained by 2 participants, both of whom had experienced injury in the past (Fig. 9; Tab. 3).

Warm-up implementation and the occurrence of injuries

In the study, 18 subjects stated that they warmed up before each training session, while 6 selected the “sometimes” option. Pre-workout warm-ups were never performed by 6 participants (Fig. 10). Of those who did implement warm-ups, 44% had never experienced an injury, while 56% had. Among those not applying warm-ups, 75% had suffered injury, while 25% had never suffered trauma (Fig. 10, Tab. 4).

Implementation of post-workout stretching and/or relaxation exercises and the occurrence of injuries

Post-workout relaxing or stretching exercises were performed for less than 10 minutes by 15 subjects, 10 of them needed 10 to 15 minutes for the exercises, while 3 participants spent more than 15 minutes on this. No post-workout exercise performance was declared by 2 subjects. Among those who applied stretching exercises, 36% had not suffered an injury, while 64% had experienced injury in the past. Among participants not applying any exercise, 1 person suffered injury while 1 did not (Fig. 11, Tab. 5).

Correlation assessment

The next stage of analysis was to determine the strength of correlations between the selected variables. Due to the nature of the assessed variables, Spearman’s rank correlation coefficient was used for determination.

Tab. 2. Total result in the FMS test

<table>
<thead>
<tr>
<th>Total result</th>
<th>(\bar{x})</th>
<th>SD</th>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total result</td>
<td>16.03</td>
<td>1.72</td>
<td>13.00</td>
<td>20.00</td>
</tr>
</tbody>
</table>

\(\bar{x}\) – średnia arytmetyczna  
SD – odchylenie standardowe  
min – najniższa wartość  
max – najwyższa wartość

Fig. 9. Profile [%] of injury and non-injury group based on the total score in the FMS test

Tab. 3. Total result in the FMS test with subject division into groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Subjects with injury in the past</th>
<th>Subjects without injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-21 points</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>14-17 points</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>&lt;14 points</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
**Fig. 10.** Profile [%] of the answer to the question “Do you use a warm-up before the actual training?”

**Tab. 4.** Using warm-up and injury history

<table>
<thead>
<tr>
<th>Warm-up</th>
<th>Subjects with injury in the past</th>
<th>Subjects without injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>No</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

**Fig. 11.** Profile [%] of the answer to the question “Do you do stretching / relaxing exercises after proper training? If so, how long do these exercises take?”

**Tab. 5.** Using stretching exercises and injury history

<table>
<thead>
<tr>
<th>Stretching exercises</th>
<th>Subjects with injury in the past</th>
<th>Subjects without injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
While assessing the strength of the correlation, the following classification according to J.P. Guilford was adopted:

\[
| r | = 0 – \text{no correlation;}
0 < | r | \leq 0.1 – \text{very weak correlation;}
0.1 < | r | \leq 0.3 – \text{weak correlation;}
0.3 < | r | \leq 0.5 – \text{moderate correlation;}
0.5 < | r | \leq 0.7 – \text{strong correlation;}
0.7 < | r | \leq 0.9 – \text{very strong correlation;}
| r | = 1 – \text{perfect correlation.}
\]

The correlations between the occurrence of past injuries and the total result in the FMS test, as well as the application of a warm-up before training and post-exercise relaxation exercises, were analysed. There was a moderate, negative correlation between the FMS result and the incidence of past injuries, indicating that the higher the final score, the less frequent injuries in the past. However, taking into account the injuries sustained in the last 6 months, a strong, statistically significant correlation was observed \((p<0.05)\). The pre-training warm-up was, on average, negatively correlated with the occurrence of the injury, while the post-training relaxation exercises demonstrated weak correlation. Data are presented in Table 6.

**Discussion**

The aim of the study was to assess the relationship between the results obtained in the Functional Movement Screen test and various aspects related to training, and the occurrence of past injuries in long-distance runners. Considering the FMS test, there is a correlation between the final result and the injuries suffered by runners. In the group of subjects who scored between 18

![Fig. 12. Profile [%] of the answer to the question “Have you ever suffered a trauma to the musculoskeletal system related to running?”](image-url)
and 21 points, 50% have experienced injury in the past. Runners who scored between 14 and 17 had an injury frequency of 64%, while 100% of those who scored below 14 had a history of injury. This leads to the conclusion that a lower FMS result may be related to a higher incidence of past injuries.

The use of the Functional Movement Screen to assess the risk of injury can be found in several scientific publications. One of them is the work by Lisman et al. [20] who conducted a study among a group of 874 navy soldiers who were assigned to 2 training cycles – short and long. In both cases, it was demonstrated that the risk of injury is higher in those candidates whose FMS score did not exceed 14. For the group with the short training cycle, the risk of injury was 1.91 times higher among those who scored below 14 points, in relation to the participants with result above 14 points. Considering the group of soldiers qualified for the long training cycle, the injury rate was 1.65 times higher for those with lower results. Summing up both groups, the risk of a traumatic event was 1.5 times higher when the result did not exceed 14 points [20]. The results obtained in the cited study seem to be consistent with the results of this study. Past injury was noted in 100% of those with a score below 14.

Another example of the use of the FMS test is a trial conducted on a floorball team comprising 23 men aged 16 to 19. The aim of the study was to detect functional disorders and abnormal movement patterns, linking them with injuries occurring in players. The average score was 17, and 12 athletes demonstrated asymmetry between the right and left sides. The data obtained from the questionnaire allowed to conclude that 12 athletes also suffered injury in the past, while 10 of them obtained a test score lower than or equal to 17 points [18]. Similar results were achieved in our research. A history of trauma was noted in 19 runners, 16 of whom obtained a score of 17 or less. Researchers assessing the floorball players suggest that the FMS test is a useful tool for detecting asymmetries and dysfunctions related to the specificity of a given sport, while showing the relationship between the test score and the history of injury [18].

There is little variation regarding the duplicated movement patterns in running. Presumably, runners with lower FMS scores implemented more varied physical activity and therefore, greater variability in movement patterns, which led to a lower risk of injury. Among the runners participating in this study, the mean score for those who had not been injured in the past was 16.45 points, while for the group of people with past injuries, this value was lower (15.79 points).

Hott et al. [21] conducted a study among professionally training runners, during the period prior to the running season. After 6 months of observation, the results were correlated with the injuries. The average result in the FMS test was 14 points. However, no correlation was found between the number of points and the frequency of injuries. Nonetheless, a dependency was noted with regard to individual motor tasks. Low results in the deep squat and active straight leg raise test correlated most strongly with the severity of injuries. Researchers believe that by referring to these 2 tests, the risk of injury can be assessed with the greatest accuracy [21]. In the author’s own research, 12 people were given 3 points for the deep squat test, 7 of whom had experienced injury in the past (58%), while 18 people achieved 2 points in the test, 12 of whom had a history of injury (66%). In the active straight leg raise test, 15 subjects achieved 3 points,
including 8 runners with previous injury (53%). Also, 15 subjects were awarded 2 points in this test, 11 of whom had had an injury in the past (73%).

It is commonly believed that one of the risk factors predisposing to injuries is the lack of warm-up before training. Based on our research, 60% of runners warm up before each training session, while 40% do not do this at all or do it sporadically. Among the subjects who did perform a warm-up, 44% had never experienced injury while 56% had had this problem. In the group of participants not implementing a warm-up or doing it occasionally, the percentage of people with injuries increased to 75%, while those without injury constituted 25%. This leads to the conclusion that the lack of warm-up exercises before training may significantly increase the risk of injury.

Michalik et al. reached similar conclusions [22]. Their research was carried out among a group of 255 people (157 men and 98 women) practicing long-distance running. Their aim was, inter alia, to identify the risk factors for sustaining injury. It was observed that runners carrying out warm-up exercises were less likely to be injured (62%), while for those who did not do this type of exercise, the risk increased (72%). Proper warm-up in running events contributes to an increase in joint mobility and improvement of overall motor coordination. Moreover, warming up influences functioning of the circulatory and respiratory system, which contributes to a delay in the fatigue process [22].

Another factor considered by many to be a risk for injury is post-workout relaxation and stretching. In our study, 28 subjects indicated that they perform this type of exercise. Only 2 people replied that they did not practice such activity, among which 1 runner suffered injury while 1 did not. Among those performing post-workout stretching exercises, 36% had not suffered injury, while as many as 64% had experienced trauma in the past. The obtained results may allow to suggest that the use of exercises aimed at stretching and relaxing the muscles does not significantly affect the prevention of injuries. As noted by Baxter et al. [23], the benefits of stretching among long-distance runners is not indicated in literature on the subject, both in terms of performance and the occurrence of delayed onset muscle soreness (DOMS), as well as a reduction in the risk of trauma development. Overload changes, such as iliotibial band syndrome, plantar fasciitis or fractures caused by overload, are the most common in runners. Baxter et al. indicate that it is not confirmed in available studies that such discomforts can be reduced by stretching exercises. The researchers concluded that this type of exercise may have significant impact on athletes in other sports, but it is doubtful that long-distance runners could benefit significantly from it, and doing so is not a solution to the problem of injury prevention. This is certainly an issue that requires further research [23].

Our own research was characterised by certain limitations, which include small size of the study group, i.e. 30 runners. It is also worth noting that this group consisted of 24 men and 6 women, which may mean that the reliability of the research relates mainly to the male sex. Another limitation may be the high variability in the frequency and volume of training among the subjects. It would be worth extending this research to include a larger and more homogeneous group of runners. Re-evaluation is also recommended after a few months, which may contribute to a more accurate interpretation of the selected issues. The results of this study indicate that a lower FMS result is associated with a higher number of past injuries. It is worth bearing in mind that there are not many studies among the literature in which individual risk factors for injury occurrence and prevention in long-distance runners are interpreted.

Therefore, further research in this area is recommended.

Conclusions

1. The total score obtained in the Functional Movement Screen test may be a predictor of injury risk in long-distance runners. A lower score in this test is associated with a higher number of past injuries.
2. Warming-up is associated with fewer injuries; therefore, it is an important element of training due to the preparation of the body for exercise and should be implemented by runners in order to prevent trauma.
3. The use of post-workout stretching exercises does not seem to be related to injury frequency in long-distance runners.

References:


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