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FUNCTIONAL FITNESS IN GIRLS AGED 11-14 PRACTISING ACROBATIC GYMNASTICS

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Abstract

Introduction. Professional training in acrobatic gymnastics carries a high risk of injury. The use of appropriate tests allows for the detection of abnormalities in the biomechanical chain of the athletes, identification of a predisposition to injury, and the introduction of appropriate corrective exercises. One of the tools used for comprehensive functional assessment is the Functional Movement Screen (FMS). The aim of the study was to assess movement patterns using the Functional Movement Screen (FMS) in girls aged 11-14 who practise acrobatic gymnastics, and to compare the results with a control group of peers who do not participate in organised physical activity. **Material and Methods.** The study was conducted on a group of 148 girls. The study group consisted of 110 female acrobatic gymnasts. The control group consisted of 38 girls who reported no participation in any organised physical activity. Functional assessment was carried out using the Functional Movement Screen. **Results.** The athletes in the study achieved significantly higher scores across all FMS tests. The highest scores were recorded among the acrobats in the ASLR right test (2.901 ± 0.316 ; $p < 0.001$) and ASLR left test (2.891 ± 0.388 ; $p < 0.001$). No statistically significant differences were found only in the shoulder mobility test. Furthermore, no statistically significant differences were observed between the gymnasts' age groups in any of the individual FMS tests. **Conclusions.** The greatest differences in the results obtained between the study groups were observed in the ASLR test. No significant differences between the study groups were found for the shoulder girdle mobility test. The findings confirm the need to incorporate exercises into the training programme aimed at improving neuromuscular control and mobility, particularly in terms of shoulder girdle mobility, which may reduce the risk of injury and improve training effectiveness.

Keywords: acrobatic gymnastics, young athletes, motor asymmetry, Functional Movement Screen (FMS)

Introduction

Functional fitness is a key component of an athlete's overall motor performance, playing a particularly important role in disciplines that require high precision of movement, such as gymnastics. Functional movement is defined as the ability to maintain an optimal balance between mobility and stability throughout the entire kinetic chain whilst performing basic movement patterns with appropriate precision and efficiency [1]. Boyle [2] emphasises that functional movement involves the integrated work of the body in all three spatial planes, which highlights the need to analyse its three-dimensional nature.

In the context of sports training, core stability (core training) plays a particularly important role, as it determines both the effectiveness and safety of movement. Properly developed motor control within the central segments of the body enables the effective generation and transfer of force, whilst reducing the risk of injuries resulting from overloading [3]. Research indicates that core stabilisation training improves the neutral position of the spine, optimal trunk alignment and load transfer along the kinetic chain [4]. Furthermore, functional stabilisation programmes can improve neuromuscular control and muscular endurance, and reduce the risk of injury in female gymnasts [5].

Artistic and acrobatic gymnastics are classified as sports with an increased risk of musculoskeletal injuries. The most common injuries affect the lower limbs, particularly when per-

forming dynamic elements such as jumps or landings [6, 7]. Albright et al. [8] demonstrated that younger gymnasts (aged 6-10) are particularly prone to upper limb fractures, whilst older athletes more frequently experience ankle sprains. The high risk of injury is associated, among other things, with early specialisation in sport and a high training volume – athletes often train for 20-30 hours a week from as early as the age of six [9, 10]. Such intense training loads may disrupt adaptive processes and contribute to overuse injuries during growth and puberty [10, 11].

Injury prevention is based on a properly planned, personalised training programme tailored to the requirements of the specific sport and the athlete's capabilities. Personalisation and appropriate progression of training loads are of key importance, as is maintaining a balance between exercise and recovery, taking into account the gender of the athletes [12, 13]. An integral part of injury prevention is functional assessment, which involves analysing stability, mobility and movement patterns using tools such as the Functional Movement Screen (FMS), which help to identify movement dysfunctions and the risk of injury [14, 15].

In view of these findings, the assessment of functional fitness in girls practising gymnastics takes on particular significance. An analysis of the quality of movement patterns and the degree of stability and mobility can provide valuable information regarding the level of motor readiness, the risk of injury and the effectiveness of the training programme used [16]. The results

obtained can form the basis for developing targeted preventive strategies and optimising training among young gymnasts.

The aim of the study was to assess movement patterns using the Functional Movement Screen (FMS) in girls aged 11–14 who practise acrobatic gymnastics, and to compare the results with a control group of peers who do not participate in organised physical activity.

Material and Methods

Participants

The study was conducted on a group of 148 girls. The study group consisted of 110 female athletes aged 11–14 who trained in acrobatic gymnastics (mean age 12.42 ± 1.10 years; mean body height 153.69 cm; mean body weight 44.96 kg). This group was divided into age subgroups: 11-year-olds ($n = 29$, mean body height 145.62 ± 5.50 cm, mean body weight 35.62 ± 5.26 kg); 12-year-olds ($n = 29$, mean body height 150.25 ± 3.68 cm, mean body weight 40.50 ± 4.43 kg); 13-year-olds ($n = 28$, mean body height 155.55 ± 6.49 cm, mean body weight 46.09 ± 5.53 kg) and 14-year-olds ($n = 24$, mean body height 163.36 ± 4.34 cm, mean body weight 57.63 ± 6.68 kg).

On average, the training programme consisted of 30% general exercises, 35% targeted exercises, and 35% specialised exercises. The control group consisted of 38 primary school pupils who reported no participation in any organised physical activity (mean age 11.41 ± 1.39 years, mean body height 157.28 ± 7.07 cm, mean body weight 55.21 ± 2.45 kg) (Tab. 1). The exclusion criteria included musculoskeletal injuries reported prior to the study or pain on the day of the examination, a history of serious injuries or orthopaedic surgery in recent months, and medical conditions that might affect the performance of the movement tests. Failure to complete all FMS test trials also resulted in exclusion from the study.

All participants were recruited on a voluntary basis and were informed about the nature of the experiment, with the research objectives and potential risks clearly explained. They were free to withdraw from the study at any time. Written consent was obtained from the legal guardians of all participants prior to the start of the study, which was conducted in accordance with the guidelines of the Declaration of Helsinki. Ethical approval was obtained from the Senate Committee on Ethics of Scientific Research at Józef Piłsudski University of Physical Education in Warsaw, Poland (SKE01–37/2024).

Functional Movement Screen test (FMS)

To assess the functional fitness of the study group, a test comprising seven exercises from the Functional Movement Screen (FMS) [1] was used. It is a diagnostic tool designed to identify functional limitations and asymmetry between the ri-

ght and left sides of the body, with each exercise analysed in the sagittal and frontal planes. The movement patterns assessed were: 'deep squat', 'hurdle step' (upper limb transfer over a hurdle), 'in-line lunge', 'shoulder mobility' (range of motion of the shoulder girdle), 'ASLR' (Active Straight Leg Raise), 'trunk stability push-up' (push-up with trunk stability), 'rotation stability' (range of rotational stability). Each movement pattern is assessed qualitatively on a scale of 0 to 3 based on compensatory movements occurring during the movement or the onset of pain. All test trials were assessed according to the following scheme: a score of 3 indicates the subject's ability to perform the movement pattern without compensation; 2 indicates performance of the movement with compensation specific to that movement pattern; 1 indicates an inability to perform the movement pattern; and 0 indicates the occurrence of pain preventing the performance of the movement pattern. The maximum score is 21, indicating high-quality movement patterns, whereas a score of 14 or less indicates significant deficits [1].

The study was conducted in September 2025 using the original FMS kit. The test was carried out in the gym in two-hour sessions starting at 9 am. Each attempt was assessed by two experts (in the event of a discrepancy in the scores, the experts consulted to agree on an appropriate score) and was carried out individually before the warm-up, under the same conditions for each participant.

Statistical analysis

Statistica 13, developed by TIBCO, Palo Alto, California, USA, was used to perform the statistical analyses. To determine the statistical significance of differences in FMS test scores between the control and study groups, a two-sample Mann-Whitney U test was used, assuming a normal distribution (two-tailed). The Kruskal-Wallis test with multiple comparisons was used to assess the significance of differences between age groups. Statistical significance was set at $p < 0.05$. Effect size was categorised as: 'insignificant' $0 < \eta^2 \leq 0.01$; 'small' $0.01 < \eta^2 \leq 0.06$; 'moderate' $0.06 < \eta^2 \leq 0.14$ and 'large' $\eta^2 > 0.14$.

Results

Compared with their peers who did not participate in organised physical activity, the female athletes achieved better results in all the FMS test trials. In the 'shoulder mobility' trial, no statistically significant differences were found; however, for the left-side assessment, the test group achieved a lower average score than the control group.

The greatest differences between the groups were observed in the ASLR (right) and ASLR (left) tests, with Z-scores of 8.611 ($p < 0.001$) and 8.163 ($p < 0.001$), respectively. In the remaining tests, the study group also achieved significantly better results,

Table 1. Somatic characteristics of the study groups.

	Control group ($n = 38$)	Study group $n = 110$			
		11-year-olds ($n = 29$)	12-year-olds ($n = 29$)	13-year-olds ($n = 28$)	14-year-olds ($n = 24$)
body height (cm)	157.28 ± 7.07	145.62 ± 5.50	150.25 ± 3.68	155.55 ± 6.49	163.36 ± 4.34
minimum	154	136	146	150	155
maximum	168	153	155	162	168
body weight (kg)	55.21 ± 2.45	35.62 ± 5.26	40.50 ± 4.43	46.09 ± 5.53	57.63 ± 6.68
minimum	51	30	38	39	48
maximum	58	44	46	53	65

Table 2. Comparison of FMS test results between the control group and the study group.

FMS trial		Control group	Study group	η^2	Z	p
Deep squat		2.102 ± 0.590	2.387 ± 0.707	0.212	2.588	0.009*
Hurdle step	R	1.692 ± 0.572	2.148 ± 0.575	0.289	3.531	0.001**
	L	1.692 ± 0.520	2.227 ± 0.604	0.360	4.416	0.001**
Inline lunge	R	2.013 ± 0.733	2.495 ± 0.614	0.315	3.842	0.001**
	L	1.846 ± 0.812	2.504 ± 0.586	0.370	4.512	0.001**
Shoulder mobility	R	2.333 ± 0.791	2.549 ± 0.696	0.128	1.566	0.117
	L	2.441 ± 0.627	2.315 ± 0.783	0.032	0.362	0.717
ASLR	R	1.769 ± 0.853	2.901 ± 0.316	0.705	8.611	0.001**
	L	1.821 ± 0.833	2.891 ± 0.388	0.669	8.163	0.001**
Trunk stability push-up		1.820 ± 0.757	2.188 ± 1.414	0.212	2.590	0.010*
Torso rotary stability	R	1.769 ± 0.853	2.255 ± 0.436	0.398	4.861	0.001**
	L	1.821 ± 0.833	2.148 ± 0.428	0.379	4.626	0.001**

Note: Effect eta squared (η^2); Z – Z statistic test; p – p value; * – $p < 0.05$; ** – $p < 0.001$.

Table 3. A comparison of the results of the FMS test for girls aged 11, 12, 13 and 14 who practise gymnastics.

FMS trial		11-year-olds	12-year-olds	13-year-olds	14-year-olds	η^2	H	P
Deep squat		2.552 ± 0.693	2.385 ± 0.561	2.290 ± 0.474	2.217 ± 0.703	0.021	4.683	0.196
Hurdle step	R	2.148 ± 0.602	2.034 ± 0.561	2.235 ± 0.562	2.150 ± 0.606	0.023	1.261	0.738
	L	2.185 ± 0.622	2.103 ± 0.673	2.294 ± 0.469	2.336 ± 0.643	0.022	4.825	0.185
Inline lunge	R	2.444 ± 0.698	2.690 ± 0.471	2.352 ± 0.785	2.411 ± 0.723	0.004	2.653	0.448
	L	2.630 ± 0.565	2.517 ± 0.574	2.471 ± 0.624	2.409 ± 0.641	0.018	1.517	0.678
Shoulder mobility	R	2.407 ± 0.747	2.552 ± 0.686	2.764 ± 0.562	2.635 ± 0.690	0.004	3.328	0.344
	L	2.259 ± 0.859	2.276 ± 0.797	2.411 ± 0.795	2.350 ± 0.797	0.030	0.514	0.915
ASLR	R	2.926 ± 0.267	2.931 ± 0.258	3.000 ± 0.000	2.875 ± 0.554	0.021	1.305	0.728
	L	2.963 ± 0.192	2.897 ± 0.404	2.823 ± 0.528	2.792 ± 0.589	0.023	1.093	0.778
Trunk stability push-up		2.407 ± 0.888	2.276 ± 0.922	2.058 ± 1.197	1.977 ± 1.116	0.007	2.356	0.502
Torso rotary stability	R	2.185 ± 0.557	2.138 ± 0.516	2.412 ± 0.618	2.282 ± 0.610	0.002	3.201	0.362
	L	2.074 ± 0.616	2.103 ± 0.489	2.235 ± 0.562	2.181 ± 0.570	0.020	1.350	0.717

Note: Effect eta squared (η^2); H – H statistic test; p – p value.

specifically in the following tests: deep squat, hurdle step (right/left), inline lunge (right/left), trunk stability push-up, rotary stability (right) and rotary stability (left) (Tab. 2).

Analysis of the FMS test results indicates that the mean scores for individual tests across the age groups remain at a similar level (around 2–3 points). This suggests that the level of basic motor skills among the female athletes was moderate to good and did not show significant differences between age groups.

No statistically significant differences were found between the age groups, as confirmed by the Kruskal-Wallis test (H) values and a significance level of $p > 0.05$ for all analysed variables. The age of the girls in the 11–14 age group did not result in any statistically significant differences in the performance of individual elements of the FMS test (Tab. 3).

Discussion

The Functional Movement Screen (FMS) is a widely used diagnostic tool across many sports disciplines, designed to assess the quality of fundamental movement patterns. The aim of this study was to determine the level of functional fitness in

female athletes training in sports acrobatics with an average training experience of 4.66 ± 2.08 years. The control group consisted of their peers who did not participate in any organised physical activity.

Our findings showed that female athletes training in acrobatic gymnastics achieved significantly higher scores in the FMS test compared to the control group, indicating better motor function.

Some researchers point to the limitations of the overall FMS test score. Both Mokha et al. [17] and Kazman et al. [18] emphasise that the overall score may have less informative value than an analysis of individual tests. Examining them separately allows for the precise identification of impaired movement patterns and supports the process of tailoring training.

In acrobatic gymnastics, particularly in the early stages of training, great emphasis is placed on learning agility and acrobatic elements performed on both the dominant and non-dominant sides [19]. The main objective of this stage of training is the harmonious and all-round development of the young athlete, encompassing the balanced development of strength, coordination, flexibility and motor control, as also emphasised in the FIG

training materials (Guidebook for Coaches) [20]. Harmonious development is regarded as the foundation for later specialisation and one of the key factors in reducing the risk of overuse injuries and compensatory movements [21].

At the same time, the growing number of young athletes is associated with an increased risk of injury resulting from the strain linked to intensive training [22]. The need to monitor and correct functional asymmetries has also been highlighted in a study by Macan et al. [23], conducted on artistic gymnasts. The observed differences in movement speed and load distribution during the execution of 'passe' and 'side passe' elements indicate the need to implement targeted training interventions. Maintaining postural stability through compensatory mechanisms may allow technique to be maintained in the short term, but their long-term use increases the risk of overloading.

The absence of significant differences between the right and left sides in our study suggests that the training programme is effectively designed to counteract the development of asymmetry.

These findings are consistent with the results of static balance studies involving children aged 6–12 who participated in physical activity sessions, including gymnastics, in which improvements in postural control were observed [24, 25].

The ability to perform fundamental motor skills (FMS) facilitates the uptake of physical activity and is a key element of children's holistic development [26]. In acrobatic gymnastics, specific control of postural stability plays a particular role. Gymnastic experience gained in childhood promotes the development of proprioceptive mechanisms, leading to more mature control and coordination of posture, similar to that seen in adults [27].

Furthermore, children aged 2–6 years demonstrate an innate ability to protect themselves in situations where there is a risk of falling [28, 29]. Studies conducted by Ozmen et al. [30] and Anderson et al. [24] emphasise that a properly implemented initial training phase helps to reduce the risk of injuries later on, a finding also confirmed by our own research on older female athletes.

Acrobatic gymnastics is a discipline requiring a high level of flexibility, agility and considerable strength in both the upper and lower body. A properly conducted initial phase of training helps to reduce the risk of injuries later in an athlete's career [24, 30, 31]. Research by Boguszewski et al. indicates that the FMS Test enables the assessment of the likelihood of physical injury and existing musculoskeletal dysfunctions [32].

The results obtained in the 'deep squat' test (2.387 ± 0.707), although they may be considered satisfactory, indicate a need to implement targeted exercises to improve movement patterns. This is important because the ability to perform a deep squat correctly has a direct impact on the quality of landing and the ability to generate force in the lower limbs, which forms the foundation of acrobatic technique. The mean scores for the age groups show a slight downward trend with age ($2.55 \rightarrow 2.22$). However, the differences are not statistically significant ($H = 4.683$; $p = 0.196$), and the effect size is small ($\eta^2 = 0.021$).

A study by Ozmen et al. [30] conducted on children aged 7.94 $\pm$ 0.32 years (15 girls, 23 boys) attending gymnastics classes shows that whole-body exercises promote the development of muscle strength in the lower limbs, upper limbs and trunk. Dericioğlu et al. [33], however, emphasise that balance is one of the key motor skills in gymnastics, and that incorporating trunk-stabilising exercises into training programmes improves sporting performance. Gymnastics training strengthens postural muscles, and the development of deep muscle endurance

enables movements to be performed in a more controlled manner, which directly impacts performance and reduces the risk of injury.

The gymnasts achieved their lowest scores in the 'trunk stability push-up' test, which indicates reduced trunk stability. A poor result in this test reflects insufficient strength and control of the superficial trunk muscles, which play a vital role in maintaining correct body alignment during dynamic acrobatic elements. Poor core stability may also increase the risk of developing spinal pain.

At the same time, the results of the 'torso rotary stability' test were significantly higher in the gymnasts than in the control group (right: 2.255 ± 0.436 ; left: 2.148 ± 0.428), indicating well-developed function of the deep muscles that act reflexively and automatically during rotational movement tasks. A gradual downward trend with age is evident ($2.41 \rightarrow 1.98$), which may suggest a lower level of core stability in older female athletes; however, the differences are not statistically significant ($p = 0.502$). The rotational stability test, therefore, allows the effectiveness of the core stabilisation system to be assessed at the neuromotor level, whilst the 'trunk stability push-up' provides a better indication of the strength of the superficial muscles.

Increased range of motion and reduced stiffness are often cited as reasons for using stretching as an injury prevention strategy [34]. The highest scores in the 'ASLR' test were obtained by the female athletes in the sample: right 2.901 ± 0.316 , left 2.891 ± 0.388 . These differences are substantial (more than 1 point compared to the control group), which indicates not only statistical significance but also high practical significance. This is also confirmed by the high values of the test statistic (8.611 for the right side and 8.163 for the left side). Importantly, the results for the right and left sides are very similar, indicating a lack of clear lateral asymmetry. This means that the differences relate more to the level of overall fitness than to an imbalance between the sides of the body. It should be noted that interviews with the coaches revealed that menarche had occurred only in the group of 14-year-old female athletes. They achieved the weakest results in the following tests: Deep squat 2.217 ± 0.703 , Inline lunge L 2.409 ± 0.641 , ASLR R 2.875 ± 0.554 , L 2.792 ± 0.589 , Trunk stability push-up 1.977 ± 1.116 . It can be assumed that this result may have been caused by biological changes (menarche) occurring in girls.

However, in the 'shoulder mobility' test, no statistically significant differences were found between the study groups. On the right side, the gymnasts achieved a higher score (2.549 ± 0.696), which may suggest a certain functional advantage on that side. This may be related to handedness or the nature of training, in which the dominant side is used more frequently.

Conversely, for the left side, the score for the gymnasts (2.315 ± 0.783) was lower than in the control group, which may indicate some functional asymmetry. Although this difference is not statistically significant, it may have practical implications – particularly in the context of injury prevention and the planning of corrective training. Specialised training programmes aimed at eliminating functional asymmetries are crucial for both optimising technique and preventing injuries – a point also emphasised by the findings of Boguszewski et al. [35].

It is also worth noting that the standard deviations are relatively high in both measurements. This indicates considerable individual variation within the group of gymnasts, which may also contribute to the lack of statistical significance.

Study limitations

The study used only the Functional Movement Screen (FMS) as a functional assessment tool. Although this test is widely used in the analysis of movement patterns, it does not allow for a comprehensive assessment of all motor abilities, such as muscle strength, power, speed or endurance.

Supplementing the diagnostic process with other motor tests, such as tests of balance, core stability, muscle strength and joint mobility, will enable a more comprehensive assessment of the athletes' physical readiness.

The difficulty in interpreting the results unambiguously makes it hard to determine precisely whether the differences observed between age groups are due to acrobatic training or to natural developmental processes at this stage. This study took little account of the biological changes associated with puberty, which may have had a significant impact on the results obtained and their interpretation.

Conclusions

Analysis of the FMS results showed that the gymnasts achieved significantly higher scores in the movement patterns analysed. The greatest differences in scores between the study groups were observed in the ASLR test, indicating significantly better mobility and stability in the lower limbs and the hip-lumbar complex among the gymnasts. No significant differences between the study groups were found for the shoulder girdle mobility test. Also, no significant differences were observed across the age groups of the acrobats, indicating a balanced level of motor preparation. The results confirm the need to incorporate exercises into the training programme aimed at improving neuromuscular control and mobility, particularly in the shoulder girdle.

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