POSTURAL PROFILES AND FOOT ALIGNMENT IN YOUNG RHYTHMIC GYMNASTS: A QUANTITATIVE CROSS-SECTIONAL STUDY

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ABSTRACT
Introduction: Proper postural development and physical symmetry are critical in rhythmic gymnastics, particularly during growth phases. The aim of the study was to analyze postural alignment, dominant leg usage, flexibility, spinal curvature, and foot structure in a sample of young gymnasts. Methodology: A cross-sectional analysis was conducted on rhythmic gymnasts from various clubs, using standardized assessments. The evaluation included sagittal spine profile classification, measurements of thoracic kyphosis and lumbar lordosis angles using an inclinometer, a frontal balance assessment of the trunk, an angle of trunk rotation measurement with a scoliometer, determination of the dominant leg (jump, pirouette, balance), and assessment of musculoskeletal complaints. Foot posture and Achilles tendon shortening were also analyzed. Results: A total of 83 rhythmic gymnasts were examined, with a mean age of 11.9 ± 1.4 years and an average training experience of 6.0 ± 2.1 years. The most commonly reported complaints included lower back pain (27.7%), knee joint pain (27.7%), hip joint discomfort (13.2%), and thigh muscle strains (12.1%). A significant proportion of the gymnasts (89.2%) demonstrated symmetrical movement patterns. Most gymnasts demonstrated a normal sagittal spine profile (43.37%), followed by lordotic (30.12%) and flat back types (25.3%). The average thoracic kyphosis angle was 24.37±8.02°, while lumbar lordosis averaged 36.17±8.54°, both within acceptable ranges. Foot posture analysis revealed a prevalence of normal arches at 83% and low arches at 17%, without flatfoot. Minimal Achilles tendon shortening was reported (grade 2-3) for 17%. Dominance patterns revealed a consistent preference for the right leg across skills. Gymnasts reporting back or hip discomfort were more likely to show asymmetry or deviations in postural balance. Conclusion: Rhythmic gymnasts display postural adaptations aligned with sport-specific demands, though early identification of deviations is essential. Monitoring spine curvature and balance symmetry may help prevent long-term injuries and optimize performance. These findings support the integration of individualized corrective programs in youth gymnastics training.

Keywords: *rhythmic gymnastics, postural, kyphosis, lordosis, flatfoot.*

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INTRODUCTION

Rhythmic gymnastics is a beautiful and elegant combination of sport, art, and dance. The sport requires a high level of physical fitness, which begins at a young age and continues to develop throughout a gymnast's career (Kritikou et al., 2014). A gymnast must possess a high level of specific qualities, primarily flexibility and strength, to achieve perfectly coordinated and precisely executed movements. Alongside mastering body technique, the manipulation of the apparatus is essential for achieving harmony and synchronization in performance.

The nature of the sport requires hundreds of repetitions over long periods, which can sometimes lead to abnormal mechanical stress on the tissues involved. If the body is not properly prepared, this may provoke various overuse syndromes (Palomares et al., 2019). When the body cannot withstand the physical demands placed on gymnasts, it often results in injuries that appear months or even years later. Typically, one side of the body is dominant, and difficult elements are performed predominantly on that side. Body composition is also a key factor in an athlete's physical development and success. However, while many experts focus on designing conditioning and apparatus technique programs, less attention is often given to developing proper posture and symmetrical body alignment (Kovalenko et al., 2020).

A study has shown a high prevalence of postural disorders and spinal deformities among rhythmic gymnasts, most commonly in the sagittal plane, though also present in the frontal plane (Bikchurin et al., 2023). Another study suggests that frontal plane disorders are more common than sagittal ones and are particularly prevalent in juvenile gymnasts compared to adolescents (Stojanovic et al., 2022). These findings are not surprising, as rhythmic gymnastics is considered an asymmetric sport. The authors also note that gymnasts often have stronger trunk extensors than flexors, likely due to the sport-specific training loads. This muscular imbalance may contribute to the absence of kyphotic posture and an increase in lordotic misalignment. Scoliotic posture, on the other hand, may result from asymmetric spinal loading caused by unilateral hip flexibility during both static and dynamic balance tasks (Stojanovic et al., 2022). Researchers have also found that rhythmic gymnasts tend to experience delayed physical maturation during childhood and adolescence. This should be taken into account when designing individualized and optimized training programs (Steinberg et al., 2005). Proper postural development and physical symmetry are critical in rhythmic gymnastics, particularly during growth phases.

The *aim* of the study was to analyze postural alignment, dominant leg usage, flexibility, spinal curvature, and foot structure in a sample of young gymnasts. Our interest was to investigate any correlation between spinal curvature and foot structure problems. The study has an informative and observational nature and preventive objectives.

METHODOLOGY

Participants

Eighty-three rhythmic gymnasts aged between 11 and 14 years old were examined amongst four main rhythmic gymnastics clubs in Sofia – Levski Triaditsa, Academic, CSKA, and Nuance NSA. The gymnasts are training for a high-level sport, which is between 24 and 36 hours per week. The testing was carried out at the beginning of the competitive period. This study was conducted in accordance with the Declaration of Helsinki for Human Research (WMA, 2008), and an institutional ethics approval was obtained from the National Sports Academy, Sofia, Bulgaria.

Protocol

A cross-sectional analysis was conducted on rhythmic gymnasts from various clubs, using standardized assessments. The evaluation included sagittal spine profile classification, measurements of thoracic kyphosis and lumbar lordosis angles using an inclinometer, a frontal balance assessment of the trunk, an angle of trunk rotation measurement with a scoliometer, determination of the dominant leg (jump, pirouette, balance), and assessment of musculoskeletal complaints. Foot posture and Achilles tendon shortening were also analyzed.

Statistical analysis

To describe the characteristics of the distribution of the variables, we applied Frequency analysis, which shows the number and percentage of cases falling into a given category. To perform additional research, we used Spearman's ρ coefficient *of Correlation.* The level of significance of $p \leq .05$ was adopted.

RESULTS

Nineteen gymnasts from each club were monitored, except for Levski Triaditsa, which had a slightly larger number – 26 participants. The aim of the testing was to involve as many gymnasts as possible within the target age group to ensure a more representative sample. The average age of the participants was 11.9 ± 1.4 years, and their average training experience was 6.0 ± 2.1 years. An additional important classification was based on performance level. In Bulgarian rhythmic gymnastics, there are three competitive categories. The highest level, "Elite," included only 11 gymnasts. This limited number reflects the strict selection criteria required for entry into this category. The next level, Category A, included 35 gymnasts, while Category B comprised 37 participants. Proper physical and technical preparation is essential in order to minimize injuries in this highly demanding sport. The results obtained from the testing are presented in the tables below.

Table 1. *Ballet and Physical Preparation in RG Clubs*

How many times per week gymnasts do:			
Ballet		**Physical preparation**	
none	26 (31%)	none	2 (2%)
1 a week	15 (18%)	1 a week	1 (1%)
2 a week	26 (31%)	2 a week	2 (2%)
3 a week	6 (7%)	3 a week	11 (13%)
4 a week	1 (1%)	4 a week	3 (4%)
5 a week	1 (1%)	5 a week	25 (30%)
6 a week	7 (8%)	6 a week	39 (47%)
Total:	**83 (100%)**	**Total:**	**83 (100%)**

Table 2. *Time Spent for Flexibility in RG Clubs*

How many minutes per week gymnasts do flexibility in:			
Hips joints		**Spine**	
–	–	0 min	1 (1%)
15 min	5 (6%)	15 min	15 (18%)
30 min	19 (23%)	30 min	34 (41%)
45 min	8 (10%)	45 min	6 (6%)
60 min	21 (25%)	60 min	16 (19%)
75 min	22 (27%)	75 min	6 (6%)
90 min	6 (7%)	90 min	2 (2%)
120 min	2 (2%)	120 min	3 (4%)
Total:	**83 (100%)**	**Total:**	**83 (100%)**

Thirty-five gymnasts have no complaints at all. The other 48 girls exhibited the following problems (see Figures 1-3).

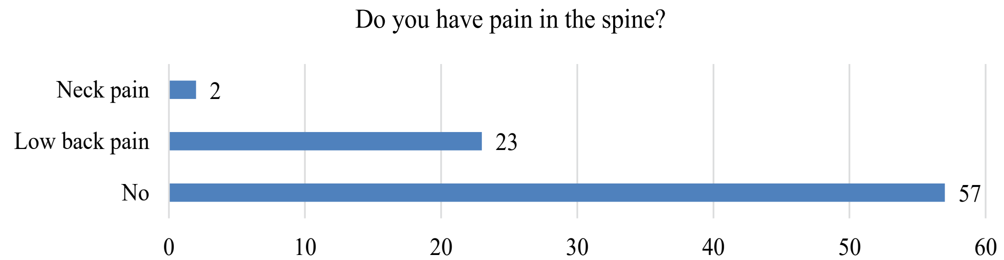

Figure 1. *Spinal Problems in Rhythmic Gymnasts*

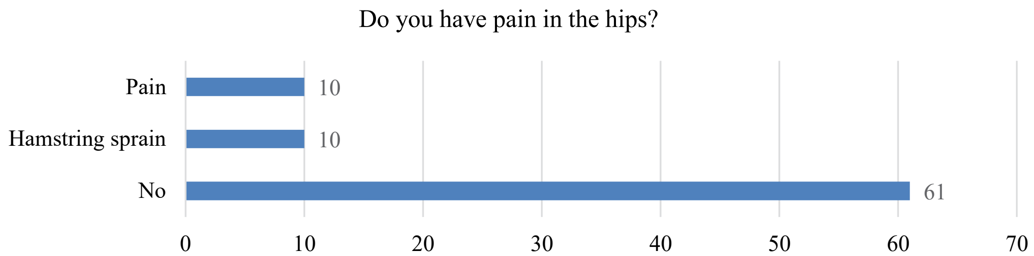

Figure 2. *Hip Problems in Rhythmic Gymnasts*

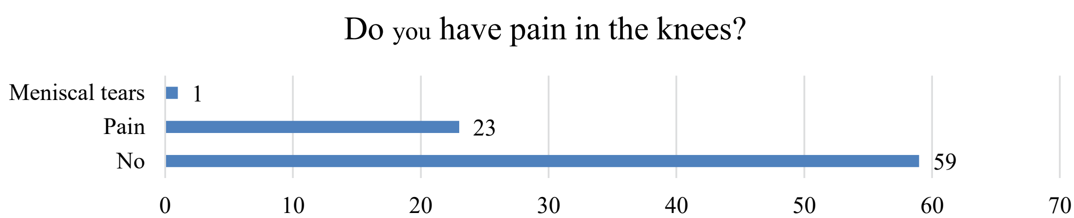

Figure 3. *Knee Problems in Rhythmic Gymnasts*

On the question: Do you have pain in the thighs? – The answers received were: 74 "No" and 7 "Yes". The last question in this section: Do you have any other complaints? – 77 gymnasts answered with "No", and another 6 reported pains in the upper limb.

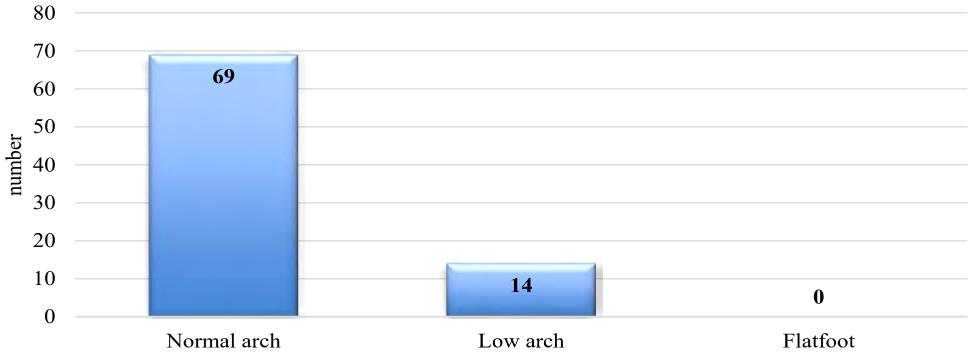

Figure 4. *Foot Conditions in Rhythmic Gymnasts*

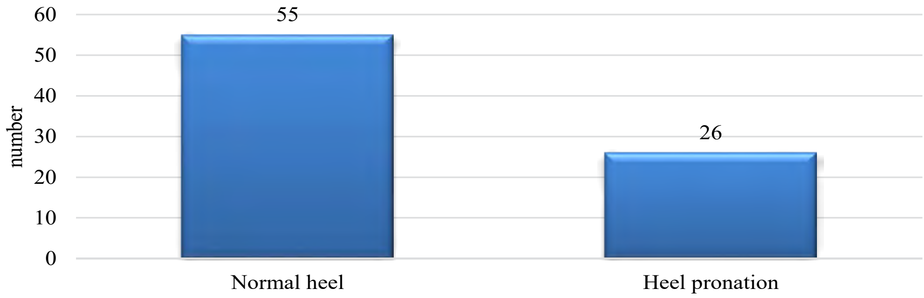

Figure 5. *Heel pronated position in Rhythmic Gymnasts*

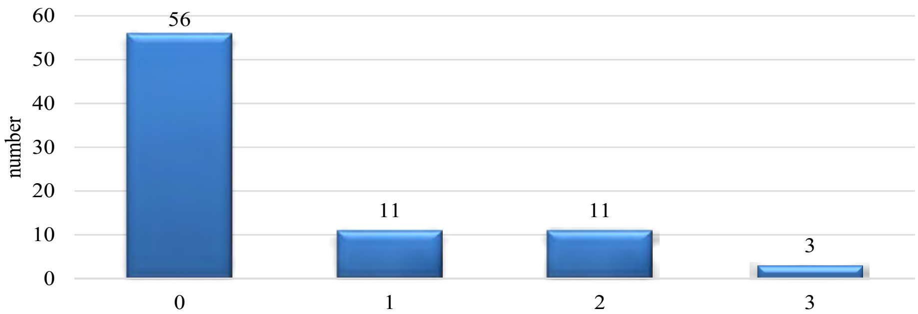

Figure 6. *Achilles Tendon Shortening in Rhythmic Gymnasts*

Grade Description of Achilles tendon shortening is as follow: 0 No shortening – able to perform a full deep squat with heels fully in contact with the ground; 1 Mild shortening – slightly reduced squat depth; heels remain in contact with the ground; 2 Moderate shortening – squat limited to the horizontal position of the thighs; heels remain grounded; 3 Severe shortening – significantly restricted squat depth; subject unable to reach thigh-horizontal level, though heels remain on the ground.

Regarding the frontal plane analysis, based on visual inspection, we identified 41 individuals (49%) exhibiting postural deviations that can be classified as a scoliotic posture without evidence of structural deformities. In terms of shoulder alignment, symmetry was observed in 48 gymnasts (58%), while 9 (11%) had a higher right shoulder and 26 (31%) had a higher left shoulder. Scapular alignment was symmetrical in 51 participants (61%), with 10 (12%) displaying a higher right scapula and 22 (27%) a higher left scapula. Regarding waist triangles, 60 gymnasts (72%) exhibited symmetrical indentations, while 6 (7%) had a more concave right waist and 17 (21%) had a more concave left waist.

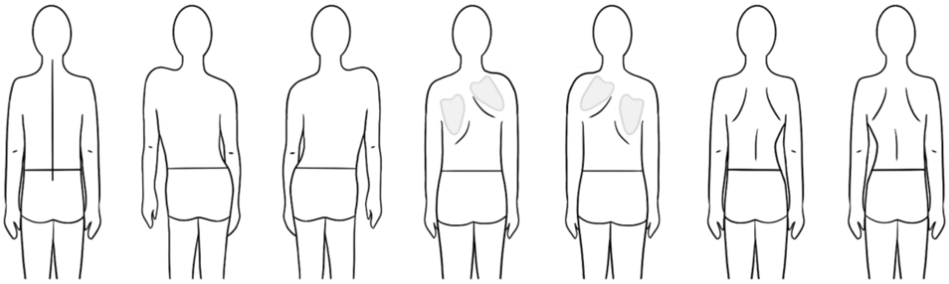

Figure 7. *Variants of Postural Deviations in the Frontal Plane Used in the Screening Software.*

To further assess the potential presence of a scoliotic deformity, we applied the Adams Forward Bend Test and measured the angle of trunk inclination using a scoliometer. Only 2 cases (2.4%) demonstrated angles exceeding 6°, suggesting a potential for structural scoliosis. Specifically, one gymnast had a 7° inclination in the thoracic region, and another showed a 9° inclination, both to the right side.

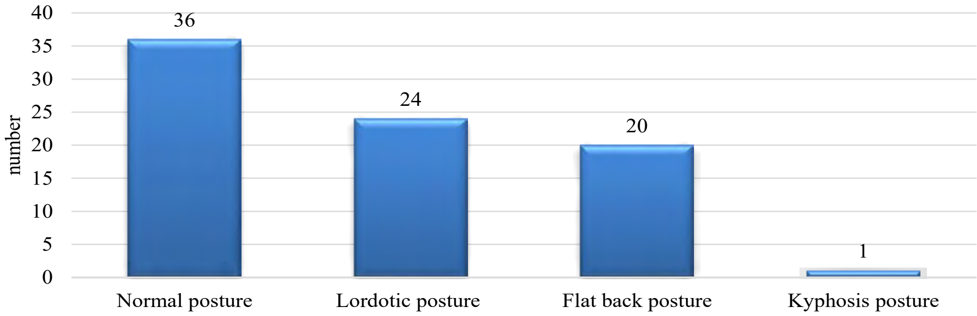

Figure 8. *Types of Sagittal Posture in Rhythmic Gymnasts*

Figure 8 shows that 44% of the tested gymnasts have normal posture. Only one gymnast was identified with a kyphotic posture, while the remaining 55% displayed either lordotic or flat back postures.

Spinal curvature was assessed using an inclinometer and categorized as follows: hypokyphosis/hypolordosis for angles less than 20°, normokyphosis/normolordosis for angles between 20° and 45°, and hyperkyphosis/hyperlordosis for angles greater than 45°.

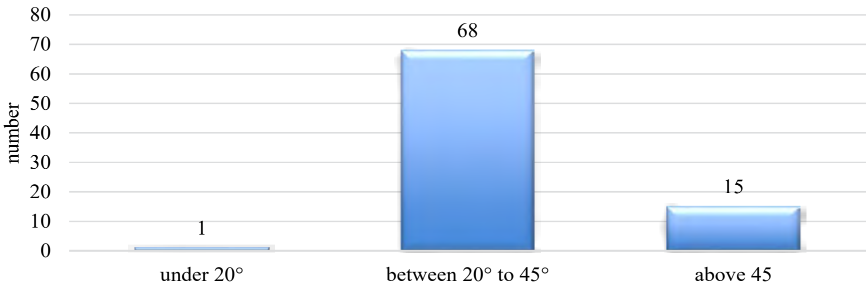

Figure 9. *Lumbar Lordosis in Rhythmic Gymnasts*

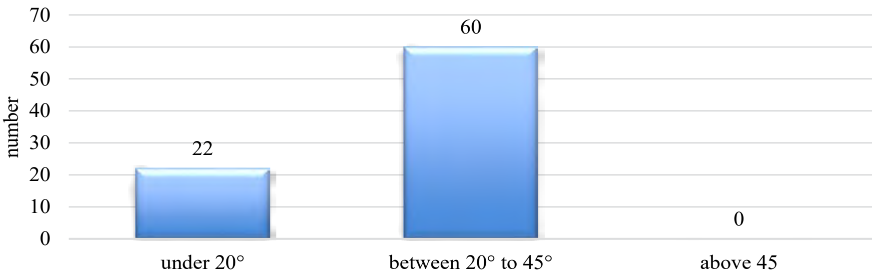

Figure 10. *Thoracic Kyphosis in Rhythmic Gymnasts*

Results of Spearman's ρ Correlation Coefficient – We investigated potential correlations between spinal issues and foot conditions; however, the only moderate correlation observed was between heel and foot pronation and the presence of a low longitudinal arch (r = .649). Other correlations between the examined parameters were present but weak. We believe that the limited number of issues identified in the tested gymnasts aged 11 to 14 may explain the lack of strong correlations found.

DISCUSSION

In rhythmic gymnastics, physical and technical development primarily occurs during the basic and advanced stages of the sport's training periodization, where the highest volume of training load is applied. Between the ages of 11 and 14, gymnasts experience rapid growth while increasing their training load (sometimes exceeding 24 hours per week). Therefore, regular monitoring of these athletes is essential to ensure safe and effective development.

Foot position, heel pronation, and Achilles tendon health should be monitored periodically, as gymnasts often develop micro or macrotraumas in this region. These injuries are frequently linked to the complaints identified during our screening process. Several studies show that muscle imbalances or body asymmetries, whether developing or already present in gymnasts, can be effectively addressed through a targeted proprioceptive training program focused on both the trunk (Di Cagno et al., 2014; Gautier et al., 2008) and lower extremities (Agostini et al., 2017; Grueva-Pancheva, 2022). Achilles shortening in rhythmic gymnastics is not unexpected, as gymnasts perform more than 95% of their elements and routines in relevé (tiptoe) or pointed position of the foot. In help comes ballet, where lots of exercises for stretching (plié and demi-plié) are used. In our study, 69% of the gymnasts have no Achilles shortening. A similar proportion of gymnasts (68%) did not present with a pronated heel position, while 32% demonstrated some degree of pronation. In contrast to a study conducted over the last 2 years, which observed 995 school-age children (Gecheva et al., 2025) and reported a flatfoot prevalence of up to 18% among school-aged children in Sofia, Chirpan, and Etropole, we did not identify any cases of flatfoot among rhythmic gymnasts. Instead, we found that 17% of the gymnasts presented with lowered arches, while the remaining 83% had normal and well-developed foot arches. Overall, the tested group demonstrated generally positive results across the foot evaluation parameters.

Regarding the scoliotic indicators assessed through the Adams Forward Bend Test, we observed a significantly lower prevalence (2.4%) compared to the findings reported from Tanchev, who identified scoliosis in 12% of 100 elite gymnasts in Bulgaria. This decline is an encouraging result, suggesting that modifications in training methodology may be contributing to a reduction in spinal deformities (Tanchev et al., 2000). Training regimes have changed significantly compared to 25 years ago. The incidence of scoliotic posture in our sample aligns closely with that of a study examining 403 school-aged children in Northern Bulgaria within the same age group (Vasileva et al., 2025).

CONCLUSION

This highlights the critical importance of precise and regular screening for elite gymnasts, who are subjected to high physical loads on a nearly daily basis. In summary, the tested group demonstrated generally positive results across the evaluated foot and spine parameters. Therefore, we consider our findings to be satisfactory. The rhythmic gymnastics clubs evaluated in Sofia appear to implement practices that contribute positively to the physical health and structural balance of their athletes. Continued monitoring and individualized assessments are recommended to maintain these outcomes and address any developing issues proactively, especially during key growth stages between the ages of 11 and 14.

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