

Dynamic function of spine and its influence by 10-week intervention program in students of performing arts

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Abstract

Background and Study Aim Students of performing arts often engage in repetitive practice routines. This can lead to overuse and muscle fatigue, which increase the risk of acute pain in the neck, arms, and shoulders. These conditions may negatively affect both quality of life and performance. Although various corrective approaches are applied in performing arts education, their relative effectiveness in improving spinal function remains a matter of practical interest. The present study aimed to evaluate the impact of a 10-week intervention program on the dynamic function of the spine in students of performing arts.

Material and Methods The 10-week intervention program was carried out twice per week for 30 minutes (Tuesday, Thursday) between October 14 and December 20, 2024. It was aimed at improving the dynamic function of the spine in 16 students (58%) of performing arts who were assigned to the experimental group (age 22.20 ± 1.40 years, weight 80.60 ± 2.80 kg, height 180.20 ± 4.40 cm). Twelve students (42%) received no intervention and formed the control group (age 22.80 ± 1.40 years, weight 76.80 ± 1.60 kg, height 176.80 ± 2.80 cm). All 28 students (100%) were bachelor's degree students (1st–3rd year) in Performing Arts and Composition at the Academy of Arts in Banská Bystrica (Faculty of Performing Arts). Standardized measures for evaluating the dynamic function of the spine (forward and side bend tests) were applied before the program (Week 1, October 14) and after completion (Week 10, December 20, 2024). The impact was evaluated using the Wilcoxon and Mann-Whitney U tests.

Results The results demonstrated significant improvements ($p < .01$) in the dynamic function of the spine in the experimental group ($N = 16$, 58%) after the 10-week intervention, particularly in forward and side bend tests. Scores in the forward bend test improved from -10.62 ± 4.24 cm in Week 1 to -2.74 ± 1.84 cm in Week 10 ($Z = 3.52$, $p < .01$, $r = .62$). Improvements ($p < .01$) were also observed in the side bend test, with lateral flexion to the right increasing from $18.56 \pm .62$ cm to $21.56 \pm .62$ cm ($Z = 3.54$, $p < .01$, $r = .62$) and lateral flexion to the left increasing from 18.36 ± 1.02 cm to $21.54 \pm .60$ cm ($Z = 3.60$, $p < .01$, $r = .64$). No significant improvements ($p > .05$) were observed in the control group ($N = 12$, 42%), suggesting that the 10-week intervention program contributed to the observed outcomes.

Conclusions The 10-week intervention program significantly improved ($p < .01$) the dynamic function of the spine in students ($N = 16$, 58%) of performing arts. These results underscore the importance of interventions in mitigating musculoskeletal risks associated with prolonged instrumental practice. Future research should explore long-term effects and broader applications of such interventions within performing arts education.

Keywords: dynamic spinal function, exercise intervention program, performing arts students, musculoskeletal health, spine flexibility

Introduction

The performing arts place high physical and psychological demands on students, requiring prolonged and repetitive practice to achieve professional proficiency. Such intensive activity often exposes the body to biomechanical stress and repetitive strain, which can compromise musculoskeletal health. Over time, these factors may contribute to muscle fatigue, postural imbalances, and acute or chronic pain in regions such as the spine, neck, shoulders, and arms. The complexity of these conditions lies in their multifactorial nature,

as they affect not only physical well-being but also the overall quality of life and performance capacity of students.

Students of performing arts are frequently exposed to conditions that test the limits of their physical resilience. These demands create a continuous interaction between technical mastery and musculoskeletal health. In this context, students, particularly those engaged in prolonged instrumental practice, are at an elevated risk of developing musculoskeletal disorders (MSDs) due to repetitive movements, static postures, and biomechanical strain on the spine [1, 2]. The demands of musical performance place substantial stress on the spinal column, which can lead to

postural imbalances, limitations in movement, and chronic musculoskeletal pain [3, 4, 5].

Students of performing arts, in particular wind instrumentalists, string players, and pianists, are known to maintain static postures for prolonged periods, which can lead to spinal misalignments and restrictions in movement [6]. Research indicates that string players, especially violinists and cellists, exhibit postural asymmetries due to uneven loading of instruments, which predisposes them to increased risks of MSDs [1, 4, 7, 8, 9, 10]. Prolonged sitting or standing is also associated with limitations in spinal movement and increased lumbar and thoracic curvature in students of performing arts [11].

Research has shown that students of performing arts with pelvic girdle pain (PGP) experience significant limitations in spinal movement, particularly in the thoracolumbar region [10, 11, 12, 13]. The presence of musculoskeletal pain in such students suggests correlations between postural dysfunctions and reduced spinal mobility, which can impair both performance and overall well-being. Younger students of performing arts are also observed to develop early postural deviations, reinforcing the importance of preventive measures and targeted interventions to preserve musculoskeletal health [7].

Students of performing arts, particularly those in music and dance, share similar biomechanical demands, especially regarding spinal mobility [11, 14]. Characteristics of mobility and sagittal curvature of the thoracolumbar segments in dance students have been shown to significantly influence spinal function, suggesting potential crossover in the ergonomic challenges faced by both music and dance students [14]. Postural education, delivered through intervention programs, has been identified as an effective method to address such challenges [10, 15, 16]. Research comparing different postural interventions highlights the benefits of exercise-based programs in improving spinal curvature and spinal mobility in university students of performing arts [17, 18].

Intervention programs lasting at least six weeks and targeting students of performing arts have shown promising results in mitigating MSDs. An eight-week intervention focused on posture correction was found to significantly ($p < .01$) improve spinal alignment and reduce MSDs in students of performing arts [10]. Manual therapy has also been shown to alleviate playing-related musculoskeletal disorders (PRMDs), leading to reduced musculoskeletal pain and improved dynamic spinal function [13]. These findings underscore the importance of incorporating intervention programs into the training regimens of students of performing arts to promote long-term musculoskeletal health.

The impact of music-related postural habits extends beyond musculoskeletal health. Students

of performing arts with reduced spinal mobility may experience compensatory motor adaptations, which place additional strain on adjacent joints and muscles [19, 20]. Reduced spinal mobility also contributes to decreased pulmonary performance, particularly in wind instrumentalists who rely on optimal postural alignment for efficient breathing mechanics. Therefore, comprehensive approaches to musculoskeletal health in students of performing arts are warranted [21].

Analysis of research findings has shown that musculoskeletal health in students of performing arts is strongly shaped by postural habits, repetitive practice, and the ergonomic demands of their disciplines. Researchers emphasize that spinal dysfunctions and postural deviations not only affect physical well-being but also compromise performance quality and long-term development. At the same time, the complexity of these conditions and the variability of intervention outcomes highlight the need for a deeper focus on targeted programs to support spinal function and musculoskeletal health in this population. Therefore, the present study was aimed at evaluating the impact of a 10-week intervention program on the dynamic function of the spine in students of performing arts.

Materials and Methods

Participants

In terms of the study aim, the target population consisted of 28 (100%) male students attending the bachelor's degree program (1st–3rd year) in Performing Arts and Composition at the Academy of Arts in Banská Bystrica, Faculty of Performing Arts. The 10-week intervention program was carried out twice per week for 30 minutes (Tuesday and Thursday) from October 14 to December 20, 2024. It aimed at improving the dynamic function of the spine (forward and side bend tests) in 16 (58%) students of performing arts: the experimental group (age 22.20 ± 1.40 years, weight 80.60 ± 2.80 kg, height 180.20 ± 4.40 cm) (Table 1). No intervention was applied to 12 (42%) students of performing arts: the control group (age 22.80 ± 1.40 years, weight 76.80 ± 1.60 kg, height 176.80 ± 2.80 cm) (Table 1).

The sample was recruited by convenience sampling, targeting male students enrolled in the optional course *Prevention of the Musculoskeletal System 1–2*, which served as the main source of recruitment. Additional recruitment was conducted through institutional emails inviting male students to participate in the research [22]. All 28 (100%) male students formed homogeneous samples (experimental and control groups) in terms of demographic and academic characteristics, ensuring consistency. The sample was considered appropriate because it accurately reflected the target population of male students attending the

bachelor’s degree program in Performing Arts and Composition (Table 2).

Convenience sampling allowed recruitment while ensuring that the sample (28, 100%) met the criteria required to address the research questions. Intentional sampling was also carried out, particularly concerning demographic factors such as age, gender, and year of study, to maintain the relevance of the study aim [10].

Evaluation of the impact of the 10-week intervention program in 16 (58%) students of performing arts was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments and/or comparable ethical standards. Approval was obtained from the Ethics Committee of the Artistic/Pedagogical Council of the Faculty of Performing Arts, Academy of Arts in Banská Bystrica (No. 001 March 14/25). All 28 (100%) students of performing arts provided written informed consent [23].

Research Design

Evaluating the impact of the 10-week intervention program in 16 (58%) students of performing arts was carried out for 10 weeks, twice per week for 30 minutes (Tuesday and Thursday) from October 14 to December 20, 2024, utilizing the design of a true experiment [24]. The 10-week intervention program, serving as the experimental stimulus, was applied to the experimental group (16, 58%) and targeted the state (S). No stimulus was applied to 12 (42%) students of performing arts – the control group (12, 42%). The period of 10 weeks (Δt) was applied to both groups, with measurements of state (S) taken at Week 1 (October 14) and Week

10 (December 20, 2024).

Twelve (42%) students of performing arts, known as the control group (12, 42%), served as the baseline of comparison. Sixteen (58%) students of performing arts – the experimental group (16, 58%) – underwent the 10-week intervention program under the guidance of the authors, who informed the experimental group about its principles (Table 3).

The 10-week intervention program was designed [25, 26] to enhance the dynamic function of the spine by targeting the musculature of the spine, abdomen, and shoulders. The approach allowed 16 (58%) students of performing arts to begin with basic exercises and controlled movements in the early stages (Weeks 1–4). They gradually advanced to more challenging exercises that incorporated functional integration and dynamic strength. The program was structured to enhance control, stability, and mobility over the 10-week period, with modifications to accommodate individual needs. Each session consisted of three components:

- Warm-up (5 min): activates spinal movements
- Intervention (20 min): focused exercises (forward and side bend test)
- Cool-down (5 min): restorative stretching and relaxation.

Warm-up, lasting 5 minutes, included activation movements designed to prepare 16 (58%) students of performing arts for intensive mobility exercises. **Intervention**, lasting about 20 minutes, consisted of focused exercises and strengthening aimed at improving coordination, stability, and mobility. **Cool-down**, lasting 5 minutes, incorporated restorative stretching and breathing exercises to aid recovery and promote relaxation.

Table 1. Anthropometric characteristics of students of performing arts

Group	Age (years; M ± SD)	Body weight (kg; M ± SD)	Body height (cm; M ± SD)
Experimental (n=16)	22.20 ± 1.40	80.60 ± 2.80	180.20 ± 4.40
Control (n=12)	22.80 ± 1.40	76.80 ± 1.60	176.80 ± 2.80

M = Mean; SD = Standard deviation

Table 2. Academic background of students of performing arts

Group	Performing Arts (n; %)	Composition (n; %)
Experimental (n=16)	12 (75%)	4 (25%)
Control (n=12)	10 (84%)	2 (16%)

n = Number of students

Table 3. Overview of the 10-week intervention program

Period of time (Δt)	Aim	Exercises
Weeks 1–2	Awareness & Activation	Basic drills, gentle stretches
Weeks 3–4	Control & Stability	Core engagement, controlled movements
Weeks 5–6	Strengthening Mobility	Strength-based spinal flexibility work
Weeks 7–8	Functional Integration	Dynamic movements and functional strength
Weeks 9–10	Advanced Progression	Integrated mobility and relaxation focus

Sixteen (58%) students of performing arts documented their progress by tracking the number of sets and repetitions and noting any challenges. They also informed the authors in case of musculoskeletal discomfort or possible pain. The authors, in turn, monitored the signs of fatigue such as shaking or loss of control. The group setting was chosen as the method of delivery because of its cost-effectiveness, the benefits of peer support, and increased engagement [27]. The 10-week intervention program was designed to maximize benefits while minimizing the risk of injury [10].

Standardized measures for evaluating the dynamic function of the spine (forward and side bend tests) [28, 29] were carried out before the program (Week 1, October 14) and after its completion (Week 10, December 20, 2024). The standardized measures included:

1. Forward Bend Test (Figure 1)
 - *Norm*: fingertips touch the ground (floor).
 - *Deviation*: fingertips do not touch the ground (floor).



Figure 1. Forward bend test

2. Side Bend Test (Figure 2)
 - *Norm*: distance of 20–22 cm.
 - *Deviation*: extension greater or less than the norm.



Figure 2. Side bend test

Statistical Analysis

Available data from 28 (100%) participants enrolled in Performing Arts and Composition were organized and presented in structured database

formats [30]. Because of the small number of students ($N = 28$, 100%), the authors employed non-parametric tests for within- and between-group comparisons. The Kolmogorov–Smirnov test (KS) indicated that the variables did not follow normal distributions. Therefore, the Wilcoxon test (W) was employed for intragroup comparisons across pre- and post-interventions. The Mann–Whitney U test (MWU) was employed for intergroup comparisons between the experimental group ($N = 16$, 58%) and the control group ($N = 12$, 42%). The significance level (p) was set at .05 and .01. Effect size (r) was calculated for W and MWU by dividing the z value by the total number of observations [31, 32, 33, 34]. Group mean values (M) \pm standard deviations (SD) were employed to summarize the descriptive data [35]. Statistical analysis was carried out using IBM SPSS Version 27.

Results

In terms of the study aim, Table 4 illustrates the differences ($p < .01$, $p < .05$) in the dynamic function of the spine in the experimental group (16, 58%) and the control group (12, 42%). Results demonstrated improvements ($p < .01$, Table 4) in the dynamic function of the spine in 58% (16) of students of performing arts who participated in the 10-week intervention program. The intervention program, focused on the musculature of the spine, abdomen, and shoulders, led to positive changes ($p < .01$) in the forward bend and side bend tests. No improvement ($p > .05$) over 10 weeks was observed in the control group (12, 42%).

Within the forward bend test (Thomayer test), the experimental group (16, 58%) improved significantly ($p < .01$) from -10.62 ± -4.24 cm in Week 1 to -2.74 ± -1.84 cm in Week 10. The Wilcoxon Test confirmed the statistical significance of these improvements ($Z = 3.52$, $p < .01$, $r = .62$). There was no change ($p > .05$) in the control group (12, 42%), which maintained an average result of -9.00 ± -2.80 cm in both Week 1 and Week 10.

The side bend test (lateral flexion) showed improvements ($p < .01$) in the experimental group (16, 58%). In particular, lateral flexion to the right increased from 18.56 ± 0.62 cm to 21.56 ± 0.62 cm ($Z = 3.54$, $p < .01$, $r = .62$). Lateral flexion to the left increased from 18.36 ± 1.02 cm to 21.54 ± 0.60 cm ($Z = 3.60$, $p < .01$, $r = .64$). There was no change ($p > .05$) in the control group (12, 42%), which maintained an average result of 19.04 ± 0.86 cm for right lateral flexion and 18.98 ± 0.96 cm for left lateral flexion.

Differences ($p < .01$, $p < .05$) in the dynamic function of the spine at Week 1 and Week 10 are illustrated in Table 5. Comparisons of the two groups in Week 1 showed no differences ($p > .05$), indicating that both groups had similar conditions at baseline. However, by Week 10, the experimental group (16, 58%) outperformed ($p < .01$) the control group (12, 42%) in all measured tests (Table 5). This

Table 4. Differences in the dynamic function of the spine in experimental and control groups

Group	Test	Week 1 (M ± SD)	Week 10 (M ± SD)	Wilcoxon Test
Experimental (n=16)	Forward bend	-10.62 ± 4.24	-2.74 ± 1.84	Z = 3.52, p < .01, r = .62**
	Side bend (Right)	18.56 ± 0.62	21.56 ± 0.62	Z = 3.54, p < .01, r = .62**
	Side bend (Left)	18.36 ± 1.02	21.54 ± 0.60	Z = 3.60, p < .01, r = .64**
Control (n=12)	Forward bend	-9.00 ± 2.80	-9.00 ± 2.80	N/A
	Side bend (Right)	19.04 ± 0.86	19.04 ± 0.86	N/A
	Side bend (Left)	18.98 ± 0.96	18.98 ± 0.96	N/A

*M = Mean; SD = Standard deviation; **Significant at p < .01; N/A = No change.

Table 5. Differences in the dynamic function of the spine at Week 1 and Week 10

Test	Experimental group (M ± SD)	Control group (M ± SD)	Mann-Whitney U Test
Week 1			
Forward bend	-10.62 ± -4.24	-9.00 ± -2.80	Z = -1.24, p > .05, r = -.24
Side bend (Right)	18.56 ± 0.62	19.04 ± 0.86	Z = -1.62, p > .05, r = -.30
Side bend (Left)	18.36 ± 1.02	18.98 ± 0.96	Z = -1.44, p > .05, r = -.28
Week 10			
Forward bend	-2.74 ± -1.84	-9.00 ± -2.80	Z = -4.20, p < .01, r = -.80**
Side bend (Right)	21.56 ± 0.62	19.04 ± 0.86	Z = -4.44, p < .01, r = -.84**
Side bend (Left)	21.54 ± 0.60	18.98 ± 0.96	Z = -4.46, p < .01, r = -.86**

*M = Mean; SD = Standard deviation; **Significant at p < .01

suggests that the 10-week intervention program enhanced the dynamic function of the spine, while the absence of an experimental stimulus in the control group (12, 42%) led to stagnation of results.

Discussion

The present study aimed to evaluate the impact of a 10-week intervention program on the dynamic function of the spine in students of performing arts. Our study observed significant enhancements (p < .01) in the dynamic function of the spine in the experimental group (16, 58%) after the 10-week intervention program. The forward bend test (Thomayer test) showed an improvement from -10.62 ± -4.24 cm in Week 1 to -2.74 ± -1.84 cm in Week 10 (Z = 3.52, p < .01, r = .62) (Table 4). There was no change (p > .05) in the control group (12, 42%), which maintained an average result of -9.00 ± -2.80 cm in both Week 1 and Week 10. The improvements align with research [36] that emphasizes the impact of intervention programs on musculoskeletal health. Changes (p < .01) in the dynamic function of the spine in 16 (58%) students of performing arts support the growing body of research, suggesting that consistent engagement in interventions counteracts the adverse effects of prolonged static postures [10, 37]. An important aspect of the 10-week intervention program was its progressive nature. It transitioned from basic awareness and activation exercises to advanced and functional integration exercises. This aligns with research [13, 38], which indicates that progressive

exercise regimens are effective in sustaining long-term musculoskeletal health benefits.

Results are consistent with research [16, 39] targeting students of performing arts. Postural education combined with intervention programs significantly (p < .01) improved the dynamic function of the spine and reduced musculoskeletal pain. Intervention programs for musculoskeletal pain demonstrated the ability to optimize treatment outcomes and enhance functional mobility. This reinforces the importance of a structured intervention strategy [40, 41]. Research on forward bend and side bend tests highlighted the importance of evaluating the dynamic function of the spine and musculoskeletal function. The forward bend test showed greater performance (p < .05) in active recreational individuals, with mean scores of ±10 cm compared to ±4.5 cm in inactive individuals. No significant difference (p > .05) was observed in the side bend test [42]. Available tests (forward bend and side bend) exhibited asymmetrical movement patterns, with one dominant side influencing the dynamic function of the spine [43]. This highlighted the relevance of these tests in assessing the dynamic function of the spine following intervention programs.

Results have significant implications for the education and training of students of performing arts. Given that students of performing arts, in particular musicians and dancers, are susceptible to musculoskeletal injuries, integrating structured movement programs within the curriculum

may be beneficial [44]. Changes ($p < .01$) in the dynamic function of the spine suggest that such interventions, lasting at least six weeks, should be incorporated into training regimens to prevent long-term musculoskeletal issues. Research [45] suggests that postural, movement-based education and ergonomic awareness programs may improve postural habits and reduce the risks of injury in students of performing arts.

Overall, the findings of this study confirm that a structured 10-week intervention program can significantly enhance the dynamic function of the spine in students of performing arts. The progressive structure of the program, focusing on spinal mobility, control, and stability, proved effective in counteracting the negative effects of prolonged static postures. These outcomes emphasize the practical value of targeted interventions in supporting musculoskeletal health and functional performance in the performing arts context.

Limitations of the Study

While the study provides valuable insights into the 10-week intervention program and its impact on the dynamic function of the spine, several limitations must be acknowledged. The sample of 28 (100%) students of performing arts consisted exclusively of male students from one institution, which limits the generalizability of the findings. Therefore, future research should aim to include a more diverse sample, incorporating female students and students from different disciplines of performing arts to enhance the usefulness of the findings [46]. The study focused on short-term outcomes. Although significant improvements ($p < .01$) were observed, the long-term retention of these benefits remains uncertain. Longitudinal research examining the sustained impact of such interventions over extended periods would be beneficial [47]. Incorporating qualitative data, such as student feedback on perceived improvements in performance and comfort, could provide deeper insights into the subjective benefits of such programs [48]. Another limitation is the reliance on standardized assessments which, although valid, may not fully capture the functional movement patterns required in different disciplines of performing arts. Future research should consider incorporating advanced analysis techniques to provide a more comprehensive evaluation of the dynamic function of the spine [49].

Future Research Directions

Future research should investigate the long-term effectiveness of the 10-week intervention to determine whether the improvements in spinal mobility are sustained over time. Expanding the sample to include female students and individuals from other performing arts disciplines (dance, acting, voice) would improve the generalizability

of the findings and reveal whether different groups respond uniquely to the intervention.

Further research should incorporate qualitative data, such as participant feedback on perceived physical comfort, performance changes, and program engagement, to complement quantitative outcomes. Comparative studies assessing different types of interventions (e.g., yoga, Pilates, manual therapy) or variations in duration and intensity may help identify the most effective and practical approaches.

Integrating discipline-specific functional tests or motion analysis technologies would provide a clearer link between improvements in spinal function and real-world performance outcomes in the performing arts.

Conclusions

The results of this study provide evidence that the 10-week intervention program improved ($p < .01$) the dynamic function of the spine in 28 (100%) students of performing arts. Given the demands placed on students because of prolonged instrumental practice, the 10-week intervention program addressed areas of dynamic spinal function. The experimental group (16, 58%), participating in targeted exercises twice per week for 30 minutes (Tuesday and Thursday), exhibited improvements ($p < .01$) in both tests (forward bend and side bend).

The 10-week intervention program led to improvements in the dynamic function of the spine, with statistical analysis confirming substantial positive changes in measurements of the forward bend and side bend. These changes ($p < .01$) suggest that incorporating regular, structured movement routines into the practice regimen of students of performing arts mitigates musculoskeletal risks associated with prolonged static postures and repetitive movements.

The results align with existing literature that emphasizes the importance of preventive interventions for individuals, students in this case, engaged in high-exertion, specialized movements. The findings also underscore the necessity of integrating musculoskeletal health programs into performing arts education. The absence of significant improvements in the control group (12, 42%) indicates that without interventions, the dynamic function of the spine stagnates or deteriorates over time. This has important implications for curriculum design in institutions of performing arts, advocating for the inclusion of movement-based programs tailored to the postural challenges faced by students of performing arts.

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Conflict of Interest

The authors declare no conflict of interest.

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