PHYSICAL EDUCATION OF STUDENTS

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Strengthening the stage: intervention targeting muscular weakening in performing arts students

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Abstract

Background and Study Aim Performing arts students, particularly musicians, face significant physical strain because of prolonged static postures and repetitive fine motor activity. These factors predispose them to performance-related musculoskeletal disorders (PRMDs). Despite increasing awareness, preventive training programs are rarely implemented in music education. This study examined the effects of a 6-week targeted intervention on postural muscle function in male performing arts students. The focus was on muscles commonly weakened by instrumental practice: deep neck flexors, musculus abdominis, and lower scapular stabilizers.

Material and Methods Twenty-six full-time male music students were assigned to experimental (N = 14, 53.85%) and control (N = 12, 46.15%) groups. The intervention group underwent bi-weekly 30-minute sessions over 6 weeks. The sessions incorporated mobility, strengthening, and control exercises. Muscle function was assessed pre- and post-intervention using standardized clinical tests. Statistical analysis was conducted using Wilcoxon and Mann-Whitney U-tests.

Results Significant improvements ($p < .01$) were found in the experimental group across all measured muscle groups, with large effect sizes. No significant changes ($p > .05$) were observed in the control group. Post-intervention comparisons confirmed significantly greater ($p < .01$) muscle function in the intervention group. A short, structured, and supervised intervention significantly enhanced ($p < 0.01$) postural muscle function among performing arts students.

Conclusions The findings support the integration of targeted physical conditioning into performing arts curricula as a preventative strategy to reduce PRMD risks and enhance physical literacy in music education.

Keywords: muscular weakening, musculoskeletal intervention, musculoskeletal health, performing arts students.

Introduction

The physical demands of performing arts training require sustained postural control and precise motor coordination over prolonged periods of practice and performance. Students engaged in intensive musical training are regularly exposed to static positions and repetitive movements that place considerable load on the musculoskeletal system. These conditions contribute to the development of muscular imbalance, particularly affecting stabilizing muscles responsible for maintaining head, trunk, and scapular alignment during instrumental practice. The resulting functional alterations may influence movement efficiency, physical comfort, and the overall capacity of students to tolerate the physical demands associated with performing arts education.

Performing arts, in particular music, require both exceptional artistic skills and significant physical endurance [1]. Music students, despite their aesthetic focus, are high-performance individuals akin to athletes. They engage in repetitive practice sessions that place significant strain on their musculoskeletal systems. However, unlike athletes, musicians often receive little formal education in physical conditioning or injury prevention [2]. Therefore, the prevalence of performance-related musculoskeletal disorders (PRMDs) among music students is alarmingly high, ranging from 39% to 87% depending on the instrument and playing posture [3]. This raises critical questions about the role of muscular strength, fatigue resistance, and physical training in sustaining healthy careers for young musicians.

Muscle weakness among music students is often insidious. It develops through prolonged static postures and fine motor repetitions. Unlike athletes who train to optimize movement competence, musicians are not trained to develop core strength, postural endurance, or biomechanical balance [4]. Retrospective ultrasound analysis of cellists with PRMDs revealed localized atrophy and dysfunction in deep stabilizer muscles. This suggests that prolonged use of improper technique may impair muscular function [4]. Muscle imbalances, particularly in the neck, shoulders, and lower back, play an important role in the development

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of overuse injuries and chronic pain. String and keyboard players are especially affected [5].

Emerging evidence suggests that targeted physical conditioning, including strength training and core stabilization, plays an important role in reducing injury risk among music students [6]. Interventions targeting proximal stability and shoulder girdle strength are associated with enhanced upper extremity endurance and a reduction in perceived exertion during performance [7]. Multidisciplinary interventions combining yoga and strength training result in significant reductions in muscle pain, perceived exertion, and psychological discomfort among performing arts students. This highlights the importance of integrating mental and physical conditioning for holistic well-being [6].

The biomechanical load placed on student musicians is intensified by fatigue, which often leads to compromised technique and compensatory movements [8]. Subtle muscle fatigue in the lower extremities significantly altered gait patterns in flatfooted participants. This finding highlights how even minor deficits in muscle function can have cascading effects on biomechanics. For musicians, this is particularly relevant during prolonged rehearsals or performances, where static postures are maintained for hours [2]. Fatigue accumulation without adequate recovery impairs neuromuscular control and increases susceptibility to acute injuries [9].

Despite widespread evidence of physical challenges in musical training, few music schools integrate structured physical education into their core curriculum [10]. Qualitative analysis revealed that less than 30% of institutions offered health and wellness support programs. Students often lacked basic knowledge of ergonomics, injury prevention, or strength conditioning [11]. The omission of musculoskeletal education creates knowledge gaps. This leaves students ill-equipped to manage the physical demands of their discipline.

Targeted, evidence-based interventions have proven effective in addressing muscular weakening and PRMDs in music students. Early research demonstrated that structured resistance training, such as a 12-week program for piano students, could significantly improve grip strength, posture control, and shoulder endurance [12]. These foundational results have since been expanded by more recent research applying holistic, multidisciplinary approaches. An educational intervention focusing on spine mobility, postural correction, and dynamic stretching led to reductions in musculoskeletal discomfort among performing arts students. Benefits remained evident during follow-up six months after the program, indicating the potential for lasting postural change [2].

Research involving university piano students has exposed high incidences of upper-body musculoskeletal strain. This strain is often linked to prolonged practice in suboptimal environments. When tailored programs integrating ergonomic correction and localized strength training were introduced, participants reported increased comfort and reduced strain. This finding underscores the importance of context-sensitive intervention models [13].

An investigation into corrective spinal training delivered over ten weeks demonstrated measurable improvements in thoracolumbar alignment and core strength among performing arts students. The intervention led to significant functional benefits and enhanced postural control. These results illustrate that even short-duration programs can yield structural changes with performance implications [2].

Taken together, these findings suggest that interventions targeting musculoskeletal health must be both evidence-based and adaptable to the unique demands of music performance. Programs combining diagnostic assessments, physical methods, corrective exercises, and ergonomic education provide comprehensive strategies that reduce injury and promote long-term literacy. As such approaches become more refined and accessible, they offer valuable tools for preserving performance capacity and supporting student well-being across the disciplines of performing arts [5, 6].

Gender differences in muscle endurance and anatomical structure also play an important role in injury exposure. Female music students, for example, have been shown to report higher rates of neck and shoulder discomfort [4]. Instrument-specific ergonomics is another underexplored area. Cellists and violinists are more prone to lateral flexion-related injuries, whereas pianists often suffer from wrist and finger overload. Understanding these nuances allows for more precise interventions tailored to both individual and instrument-specific needs [6].

Despite mounting evidence supporting the role of physical training, implementation remains limited. Barriers include lack of faculty awareness, curriculum constraints, and resistance to non-musical content. Institutional inertia and limited funding often hinder health-focused curricular reforms. Therefore, stigma around physical pain remains, with students often reluctant to report symptoms for fear of being perceived as weak or uncommitted [10].

“Strengthening the stage” requires systemic change. Institutions must move beyond reactive injury management and embrace proactive health education. This includes inserting musculoskeletal health modules into the curriculum, offering supervised physical training sessions, and promoting a culture of wellness. Partnerships with physiotherapists and ergonomics specialists can bridge the gaps between artistic demands and physical sustainability [6]. As music students

continue to face high physical demands, the integration of structured interventions becomes both beneficial and essential for sustaining performance over time.

Despite increasing recognition of PRMDs and growing advocacy for preventive conditioning in music education, important gaps remain in the literature. First, many existing studies primarily rely on self-reported pain reduction and subjective measures, whereas fewer investigations employ objective clinical assessments of specific postural muscle function. Second, although intervention programs are described, limited evidence exists regarding short-term, time-efficient models that are feasible for integration into university curricula without disrupting artistic training schedules. Third, little research has simultaneously targeted deep neck flexors, deep abdominal stabilizers (m. transversus abdominis), and lower scapular stabilizers. These muscle groups are involved in postural endurance and neuromuscular control during instrumental performance. The present study aims to examine the effects of a structured 6-week neuromuscular intervention targeting these key postural muscle groups on objectively assessed muscle function in male performing arts students. By focusing on clinically graded outcomes and curriculum-compatible intervention formats, this study seeks to provide practical and scalable evidence supporting preventive strategies in performing arts education.

Materials and Methods

Participants

The study involved 26 performing arts students (N = 26, 100%), divided into two groups: the experimental group (N = 14, 53.85%) and the control group (N = 12, 46.15%). All participants were male full-time students enrolled in performing arts programs (i.e., Faculty of Performing Arts, Academy of Arts in Banská Bystrica). All participants met the inclusion criteria of active instrumental practice and regular engagement in academic performance training. Group allocation was determined by existing class cohorts and scheduling logistics, consistent with quasi-experimental designs. Exclusion criteria included any diagnosed neuromuscular disorders, acute musculoskeletal injuries, or ongoing physiotherapeutic treatments.

Descriptive statistics for the two groups are presented in Table 1. The mean age of the experimental group was 21.28 ± 1.24 years, and for the control group it was 20.96 ± 1.48 years, with no statistically significant difference between them ($t(24) = .592$, $p = .560$). Mean weight was 68.64 ± 4.82 kg in the experimental group and 68.28 ± 4.42 kg in the control group ($p = .844$). Mean height was 174.42 ± 4.26 cm (experimental) and 176.64 ± 2.86 cm (control), with no significant difference ($p = .128$).

Daily practice time averaged 2.68 ± .82 hours in the experimental group and 2.62 ± .68 hours in the control group ($p = .840$), indicating comparable instrumental workloads. The mean length of musical training (career duration) was 16.28 ± 1.86 years in the experimental group and 16.84 ± 1.26 years in the control group ($p = .373$).

Participants represented various instrumental families. In the experimental group, 42.86% played wind instruments, 28.57% string instruments, and 28.57% keyboard instruments. In the control group, 33.33% were wind players, 50% string players, and 16.67% keyboard players.

Independent samples t-tests showed no statistically significant differences ($p > .05$) between the experimental and control groups on any baseline variable, including age, weight, height, daily practice duration, or musical experience. These findings confirm the comparability of the two groups at the start of the intervention, supporting the internal validity of subsequent analysis.

Participants provided written informed consent prior to the commencement of the study. Participation was voluntary, and the study protocol was approved by the Ethics Committee of the Artistic and Pedagogical Council of the Faculty of Performing Arts, Academy of Arts in Banská Bystrica (Approval No. 01, FMU-AU/26) in accordance with the ethical principles of the Declaration of Helsinki [14].

Table 1. Characteristics of performing arts students (N = 26, 100%)

Variable	Experimental group	Control group
Anthropometrics		
Age (years; M ± SD)	21.28 ± 1.24	20.96 ± 1.48
Weight (kg; M ± SD)	68.64 ± 4.82	68.28 ± 4.42
Height (cm; M ± SD)	174.42 ± 4.26	176.64 ± 2.86
Instruments		
Wind (N; %)	6; 42.86%	4; 33.33%
String (N; %)	4; 28.57%	6; 50%
Keyboard (N; %)	4; 28.57%	2; 16.67%
Practice		
Day (hours; M ± SD)	2.68 ± .82	2.62 ± .68
Career (years; M ± SD)	16.28 ± 1.86	16.84 ± 1.26

Note. N = Number, % = Percentage, cm = centimeter, kg = kilogram, M = mean, SD = standard deviation.

Research Design

This study employed a quasi-experimental controlled design with two parallel groups: an experimental group (N = 14, 53.85%) and a control group (N = 12, 46.15%). Group allocation was based on existing class enrollment and cohort structure rather than individual randomization. Although participants were not randomly assigned, baseline comparability between groups was statistically

verified across demographic and practice-related variables, supporting internal validity. The design adhered to established guidelines for physical conditioning trials in performing arts health research [15].

The recruitment process was conducted in accordance with ethical guidelines, ensuring voluntary participation, anonymity, and confidentiality [16]. Participants were informed about the study's purpose, procedures, and potential risks and benefits. The right to withdraw at any time without consequence was guaranteed. All data were anonymized, securely stored, and used strictly for research purposes.

The intervention lasted six weeks (Δt = 6 weeks) and was implemented 2x/week, every Tuesday and Thursday, with each session lasting 30 minutes. Baseline assessments (pre-intervention) were completed during Week 1 (October 14, 2025), and post-intervention assessments during Week 6 (November 20, 2025). All sessions were carried out in small-group settings within the university movement space (i.e., Ďatelinka, approximately 60 m^2), equipped with exercise mats and light-to-moderate resistance bands [17]. No specialized biomechanical or instrument-specific equipment was required. Sessions were conducted in small groups (experimental group) under the supervision of instructors with an academic background in Physical Education and neuromuscular training.

The scheduling format (2x/30 minutes weekly) was integrated into the existing semester timetable without altering core artistic coursework. These contextual characteristics suggest that replication is feasible in institutions with access to basic movement facilities and qualified supervision.

The intervention was designed to address muscular weakening patterns often observed in music students, with a primary focus on deep neck flexors, musculus abdominis, and lower scapular stabilizers [3, 6]. Although the phased structure (mobility-strengthening-control) reflects established principles of neuromuscular conditioning, the novelty of the present intervention lies in three key aspects. First, the program simultaneously targets deep cervical stabilizers, transversus abdominis, and lower scapular stabilizers. These muscle systems are biomechanically interdependent yet rarely examined together within controlled performing arts cohorts. Second, the intervention duration (6 weeks; 2x/30 minutes weekly) was intentionally designed as a minimal-dose, curriculum-compatible model to enhance institutional feasibility. Third, results were evaluated using standardized clinical muscle grading rather than self-reported symptom reduction. This enabled objective assessment of neuromuscular adaptation. The study focuses on a homogeneous sample of male performing arts students, allowing clearer interpretation of postural muscle responses within defined demographic groups.

Each session followed standardized, progressive formats consisting of mobility, control, and strengthening (Table 2). No participant advanced to higher dosage parameters unless correct technique was maintained across all prescribed repetitions or hold durations.

Table 2. 6-week intervention for muscular weakening

Week	Focus	Exercise
1-2	Mobility & Activation	- Chin tucks - Scapular setting - Cat-cow mobilization - Pelvic tilts - Diaphragmatic breathing - Pectoralis doorway stretch - Shoulder blade squeezes - Supine thoracic rotations
3-4	Strengthening & Reeducation	- Prone Y-T-W holds - Bird-dog with neutral spine - Wall planks - Neck flexor isometrics - Wall angels - Glute bridge with arm drive - Resistance band rows - Levator scapulae stretch
5-6	Control & Integration	- Standing "W" posture holds - Dead bug with resistance band - Seated thoracic rotation with arm reach - Scapular retraction rows - Wall push-ups - Bird-dog with leg extension and cervical alignment - Arm wall slides - Supine chin tuck with overhead reach

During Weeks 1-2 (mobility and activation), exercises were performed in 2 sets of 8-10 controlled repetitions or 15-20-second holds (for isometric tasks), with 30-second rest intervals between sets. Emphasis was placed on low-load activation, breathing coordination, and movement precision.

During Weeks 3-4 (strengthening and reeducation), exercises progressed to 2-3 sets of 10-12 repetitions or 20-30-second holds, with 30-45 seconds of rest between sets. Resistance bands (light to moderate tension) were introduced

where applicable (e.g., rows, dead bug variations). Progression was contingent upon the participant's ability to maintain neutral alignment and avoid compensatory activation patterns.

During Weeks 5-6 (control and integration), exercises were performed in 3 sets of 12-15 repetitions or 30-40-second holds, with 45-second rest intervals. Functional integration tasks required sustained postural control combined with coordinated limb movement. Advancement was permitted only when participants demonstrated consistent motor control quality. This was defined as maintenance of cervical alignment, scapular stability, and abdominal activation without visible compensation or tremor.

Over the 6-week intervention, all sessions were supervised directly by the research team to ensure protocol fidelity. Attendance was recorded at each session. Adherence rate was calculated as the percentage of completed sessions out of the total 12 prescribed sessions. Participants in the experimental group attended on average 92.3% (± 5.8%) of scheduled sessions. Attendance ranged from 10 to 12 sessions per participant. No participant attended fewer than 10 sessions (83.3%), and no dropouts occurred during the intervention period.

Intervention fidelity was monitored using structured observation checklists documenting exercise completion, adherence to prescribed sets and durations, and compliance with predefined movement quality criteria. Any deviations from the protocol (e.g., reduced hold time due to fatigue or compensatory movement) were documented and corrected immediately during supervision. No adverse events or musculoskeletal injuries were reported during the intervention period.

The control group did not receive structured physical training and maintained their usual academic and instrumental practice routines throughout the study period. Participants were specifically asked not to initiate new strength, core, or rehabilitation programs during the six-week period. Informal weekly check-ins were conducted to confirm adherence to this instruction. No participant reported engaging in additional targeted neuromuscular training.

To minimize contamination between groups, intervention sessions were scheduled separately from shared coursework. Participants were requested not to discuss specific exercise content with peers from the control cohort.

Standardized measures for evaluating muscular weakening, in particular the deep neck flexors, musculus abdominis, and lower scapular stabilizers [18], were employed at baseline (Week 1, October 14, 2025) and again after the intervention (Week 6, November 20, 2025):

• *Deep Neck Flexors (m. longus colli, m. longus capitis)*

These muscles are important for cervical spine stabilization, prevention of neck pain (cervical syndrome), and maintenance of upright posture, particularly in today's lifestyles. The subject lies in a supine position with knees bent (to relax abdominal muscles). The subject performs a chin tuck, lifting the head toward the chest just enough so that a pillow could fit under the chin. The ability to maintain the position without activating superficial neck muscles is observed.

Grade 0 - No activity: No visible or palpable contraction; complete weakness. Grade 1 - Minimal activity: Palpable or visible muscle contraction without actual movement. Grade 2 - Basic function: Able to perform the motion (head flexion) through full range in a gravity-eliminated position (lying down), indicating functional activation.

• *Musculus Abdominis (m. transversus abdominis, m. obliquus internus)*

These muscles are important for core stability, lumbar spine support, and prevention of low back pain. Proper activation is essential in both daily and athletic movements. The subject lies on their back with knees bent and feet flat on the floor. The subject performs an abdominal hollowing maneuver, drawing in the abdominal wall toward the spine without movement of the pelvis or rib cage. The test assesses the ability to isolate deep abdominal activation.

Grade 0 - No activity: No contraction detected. Grade 1 - Minimal activity: Slight muscle tension without visible movement. Grade 2 - Basic function: Able to perform isolated abdominal wall movement (in a supine position) without engaging superficial muscles.

• *Lower Scapular Stabilizers (m. serratus anterior, m. lower trapezius, m. rhomboideus)*

These muscles are important for scapular positioning, shoulder stability, and prevention of neck and shoulder pain. Dysfunction often leads to abnormal scapular movement and impingement syndromes. The subject lies in a prone "superman" position with the arms extended overhead. The subject attempts to lift the arms off the ground while maintaining scapular control and avoiding upper trapezius compensation. Observers evaluate coordination, scapular motion, and symmetry.

Grade 0 - No activity: No movement of the scapula or contraction detected. Grade 1 - Minimal activity: Slight scapular movement or contraction without arm motion. Grade 2 - Basic function: Able to raise the arms with proper scapular stabilization and without compensatory movement.

The clinical system (i.e., Grade 0-2) employed

in this study was selected on purpose from standardized and widely accepted functional muscle testing frameworks rather than as a novel diagnostic instrument. The aim was not to develop a new classification system but to apply an established, clinically interpretable grading method to objectively assess postural stabilizing muscle function within a preventive performing arts context. Such scales are frequently used in musculoskeletal and rehabilitation research due to their feasibility, reproducibility, and suitability for small-sample experimental designs.

The selected muscle function tests are derived from established manual muscle testing frameworks with documented clinical reliability and validity in musculoskeletal and rehabilitation research [18]. To enhance measurement reproducibility, all assessments were performed by the same examiners (authors), who had prior clinical training in functional muscle testing and completed standardized procedural calibration before data collection. A pilot familiarization session was conducted to ensure consistent grading criteria, palpation technique, and movement observation standards. Standardized verbal instructions and positioning protocols were used across all participants to minimize inter-session variability.

In the present study, the grading system served as a functional screening tool capable of detecting meaningful neuromuscular changes over a short intervention period. Its simplicity allows practical implementation in educational settings without requiring specialized equipment, thereby enhancing translational applicability. The methodological contribution of this study lies not in scale refinement but in the structured and systematic application of standardized clinical grading to evaluate targeted neuromuscular adaptation in performing arts students.

While the absence of individual randomization may limit full experimental control, baseline equivalence testing indicated no significant differences between groups prior to the intervention. This reduces the likelihood that observed post-intervention effects were attributable to pre-existing group disparities.

Statistical Analysis

Statistical analysis was conducted using IBM SPSS Statistics (Version 24.0; IBM Corp., Armonk, NY, USA). Descriptive statistics, including means (M) and standard deviations (SD), were calculated to summarize participant demographics and results [19].

The sample size was determined by cohort availability within the performing arts program during the academic semester rather than by a priori power calculations. Eligible students meeting the inclusion criteria were invited to participate, resulting in a total sample of 26 participants. Given the large effect sizes observed in the primary outcomes (r = .56-.74), post hoc estimation indicates that the study achieved adequate statistical power (> .80) to detect between-group differences at α = .05 for non-parametric comparisons. While larger samples would increase generalizability, the present sample size is comparable to previous intervention studies conducted in musician populations [2, 17].

In terms of assessing the normality of data distributions, the Shapiro-Wilk test was employed [20]. Results indicated violations of normality for some variables, prompting the use of non-parametric procedures for inferential analysis. However, anthropometric variables, including age, height, and weight, conformed to normal distribution assumptions. Therefore, independent-samples t-tests were employed to assess group differences at baseline.

Non-parametric methods were employed in alignment with methodological guidelines for research involving small sample sizes and data that deviate from normal distribution assumptions. Within-group differences (pre- vs. post-) were analyzed using the Wilcoxon test, while between-group comparisons (experimental vs. control) were analyzed using the Mann-Whitney U-test [21]. The level of statistical significance was set at $p < .05$. For all significant results, effect sizes (r) were calculated using the formula $r = Z / \sqrt{N}$, where N is the total number of observations. Effect sizes were interpreted using Cohen's [22] classification: small (r = .10), medium (r = .30), and large (r = .50). Results are reported with corresponding test statistics, p-values, and effect sizes, ensuring adherence to established guidelines in sports and health sciences research.

Results

Within-group comparisons revealed statistically significant improvements ($p < .01$) in all assessed muscle groups in the experimental group following the 6-week intervention (Table 3). Deep neck flexor function increased markedly from baseline (.57 ± .51) to post-intervention (1.57 ± .51). The Wilcoxon test confirmed a highly significant change ($Z = 3.27$, $p < .01$) and a large effect size (r = .61). Musculus abdominis activation demonstrated significant enhancement, improving from a pre-intervention mean of .71 ± .46 to 1.57 ± .51 after the intervention ($Z = 3.20$, $p < .01$; r = .60). Lower scapular stabilizer function followed the same pattern. It increased from .57 ± .51 at baseline to 1.57 ± .64 at post-intervention, with statistical significance ($Z = 3.27$, $p < .01$) and a large effect size (r = .61) (Figure 1).

No statistically significant within-group changes ($p > .05$) were observed in the control group across the six-week period (Table 3). Deep neck flexors slightly decreased from .50 ± .52 to .33 ± .65, but this change was not significant ($Z = .81$, $p > .05$; r = .16).

Musculus abdominis showed a minor decline from .50 ± .52 to .41 ± .51 (Z = .44, p > .05; r = .09). Lower scapular stabilizers demonstrated a small, non-significant increase from .50 ± .52 to .75 ± .62 (Z = 1.13, p > .05; r = .23) (Figure 1).

Between-group comparisons at baseline confirmed no statistically significant differences (p > .05) between the experimental and control groups in any of the assessed muscle functions (Table 4). Deep neck flexors (Z = -.35, p > .05), musculus abdominis (Z = -1.09, p > .05), and lower scapular stabilizers (Z = -.35, p > .05) demonstrated comparable baseline levels, indicating homogeneity between groups prior to the intervention.

Post-intervention intergroup analysis revealed statistically significant differences (p < .05) favoring the experimental group across all measured variables (Table 4). Deep neck flexor function was

Table 3. Intragroup (within) comparisons of performing arts students (N = 26, 100%)

Muscles (M ± SD)	Pre- (Week 1)	Post- (Week 6)	Wilcoxon test (p)
Experimental group			
Deep neck flexors	0.57 ± 0.51	1.57 ± 0.51	Z = 3.27, p < .01, r = 0.61**
Musculus abdominis	0.71 ± 0.46	1.57 ± 0.51	Z = 3.20, p < .01, r = 0.60**
Lower scapular stabilizers	0.57 ± 0.51	1.57 ± 0.64	Z = 3.27, p < .01, r = 0.61**
Control group			
Deep neck flexors	0.50 ± 0.52	0.33 ± 0.65	Z = 0.81, p > .05, r = 0.16
Musculus abdominis	0.50 ± 0.52	0.41 ± 0.51	Z = 0.44, p > .05, r = 0.09
Lower scapular stabilizers	0.50 ± 0.52	0.75 ± 0.62	Z = 1.13, p > .05, r = 0.23

Note. N = number of participants; % = percentage; M = mean; SD = standard deviation; p = significance level; Z = Wilcoxon test statistic; r = effect size. ** p < .01.

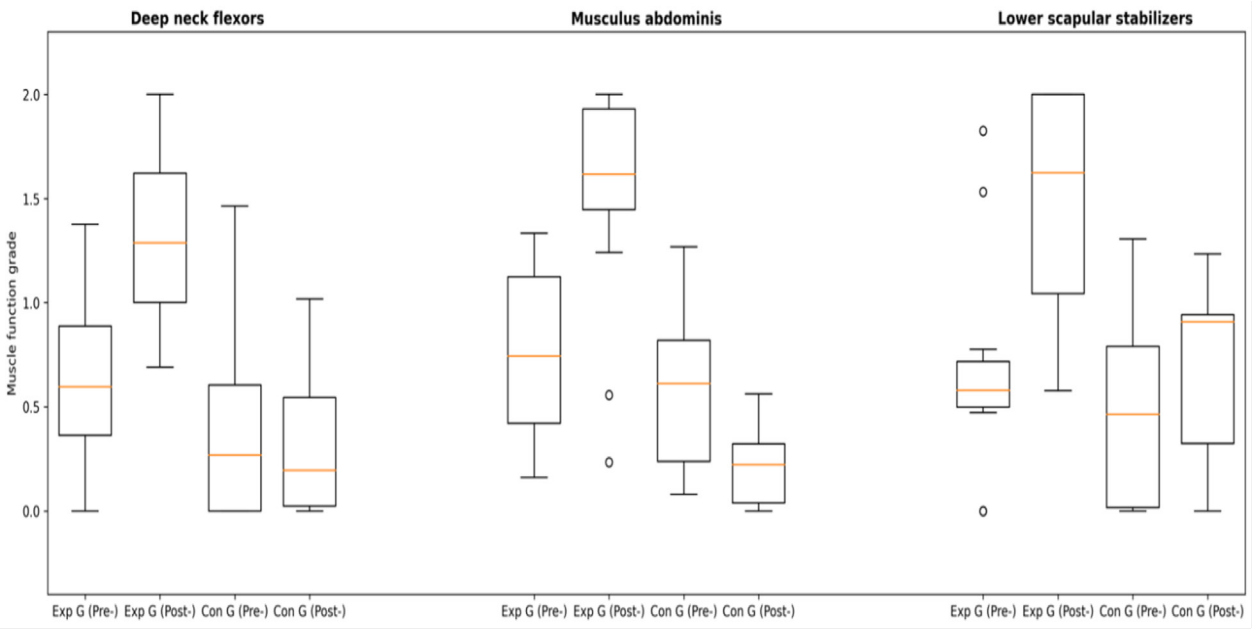

Figure 1. Distributions of grades in experimental (Exp G) and control (Con G) groups (N = 26, 100%)

Table 4. Intergroup (between) comparisons of performing arts students (N = 26, 100%)

Muscles (M ± SD)	Experimental group	Control group	Mann-Whitney U-test (p)
Pre- (Week 1)			
Deep neck flexors	0.57 ± 0.51	0.50 ± 0.52	Z = -0.35, p > .05, r = -0.07
Musculus abdominis	0.71 ± 0.46	0.50 ± 0.52	Z = -1.09, p > .05, r = -0.21
Lower scapular stabilizers	0.57 ± 0.51	0.50 ± 0.52	Z = -0.35, p > .05, r = -0.07
Post- (Week 6)			
Deep neck flexors	1.57 ± 0.51	0.33 ± 0.65	Z = -3.07, p < .01, r = -0.72**
Musculus abdominis	1.57 ± 0.51	0.41 ± 0.51	Z = -3.79, p < .01, r = -0.74**
Lower scapular stabilizers	1.57 ± 0.64	0.75 ± 0.62	Z = -2.85, p < .01, r = -0.56**

Note. N = number of participants; % = percentage; M = mean; SD = standard deviation; p = significance level; Z = Mann-Whitney test statistic; r = effect size. ** p < .01.

significantly higher in the experimental group (1.57 ± .51) compared to the control group (.33 ± .65), with a large effect size ($Z = -3.07$, $p < .01$; $r = -.72$). Musculus abdominis differed significantly between groups, with the experimental group achieving substantially higher scores (1.57 ± .51 vs. .41 ± .51; $Z = -3.79$, $p < .01$; $r = -.74$). Lower scapular stabilizer function was significantly greater in the experimental group (1.57 ± .64) compared to controls (.75 ± .62), with a large effect size ($Z = -2.85$, $p < .01$; $r = -.56$).

Discussion

The results of the study confirm that short-term (i.e., 6 weeks) muscular intervention significantly ($p < .01$) enhances postural muscle function in performing arts students, particularly in the deep neck flexors, musculus abdominis, and lower scapular stabilizers. The improvements indicate that even relatively short-duration, controlled physical programs may play protective and corrective roles in performance-related musculoskeletal health in performing arts students [23].

The results align with recent evidence from randomized trials on musicians, where strengthening programs focusing on spinal alignment and shoulder control reduced both the intensity and frequency of musculoskeletal complaints [24]. Activation of the deep neck flexors aligns with cervical stabilization results observed in resistance-based programs for musicians who engage in prolonged seated practice [25].

The improvements in the deep neck flexors found in this study resonate with integrated physical therapy interventions that combined strength training and kinematic analysis in music students, resulting in improved postural endurance and playing technique [26]. Similar interventions that addressed muscle imbalances in the upper body demonstrated measurable benefits in scapular mechanics, particularly for students playing violin and flute [27].

The improvements of the musculus abdominis observed in the current study mirror earlier findings showing that strengthening core muscles enhanced lumbar control and decreased fatigue symptoms during performance [28]. This reflects the interdependence between spinal stability and extremity movement. These concepts are often neglected in performing arts pedagogy but are important for healthy technique.

Improvements in the lower scapular stabilizers indicated enhanced neuromuscular control. This is an essential factor in preventing shoulder impingement and maintaining upper limb precision under fatigue. This supports results from interventions that reduced shoulder strain in string musicians through serratus anterior and trapezius reinforcement [11].

The phased structure of this intervention, combining mobility, strengthening, and control, is consistent with established frameworks advocating progressive and functional training in musicians at risk of PRMDs [28]. Education and activation strategies, when combined, provide multidimensional benefits in postural control and proprioceptive awareness.

Incorporating group-based delivery was a strategic choice that builds upon findings that small-group physical training enhances peer accountability and adherence among student musicians [17]. Group dynamics may reduce stigma associated with physical weakness or injury in university environments.

Preventative strategies are recommended in recent literature as the primary mode of protecting musicians from injury, particularly when applied early in their training trajectory [29]. This aligns with our findings, as preemptive muscle conditioning was effective even before any clinical symptoms had fully manifested.

In terms of a pedagogical standpoint, the originality of this study lies in proposing a structured 2x/30-minute weekly neuromuscular module explicitly designed for integration within existing university timetables without displacing artistic coursework. While previous health initiatives in music institutions often rely on optional workshops, short-term seminars, ergonomic lectures, or multidisciplinary wellness programs, they are frequently extracurricular, symptom-driven, or resource-intensive.

The present model demonstrates that a minimal-dose, supervised stabilization program can be embedded within standard semester structures while maintaining high adherence (92.3%) and producing significant objective results. This positions the intervention not as auxiliary health support but as a scalable curricular component aligned with performing arts training demands. The framework therefore advances existing approaches by offering a time-efficient, institutionally feasible, and performance-compatible conditioning structure that can be systematically implemented rather than sporadically delivered.

In terms of a curriculum standpoint, incorporating such interventions in standardized formats may close the current gap between physical literacy and performance training. Many music institutions lack embedded health modules, despite the high injury prevalence among students [30]. Institutional resistance to including non-musical content in the curriculum has been identified as a persistent barrier to implementing Physical Education for musicians, even when such content supports their performance health [2]. Yet, research consistently shows that students respond positively when they understand the practical impact on their practice quality and career longevity.

The results support the use of brief yet focused interventions. Similar to this study's 6-week model, interventions as short as ±6 weeks have demonstrated statistically and clinically meaningful outcomes in muscle endurance and postural coordination [25]. These can be feasibly embedded within semester schedules without conflicting with musical instruction.

There is increasing evidence that movement literacy should be recognized as an artistic skill in itself, particularly in disciplines involving repetitive motor patterns and high biomechanical demands [28]. Physical training should be viewed not as external to artistry but as foundational to sustainable performance.

In terms of a theoretical perspective, the present findings contribute to the growing integration of neuromuscular control principles within performing arts pedagogy, where postural regulation and fine motor coordination are increasingly understood as interdependent systems rather than isolated functions [31, 32]. Instrumental performance requires sustained postural endurance combined with fine motor precision. Such combinations depend on efficient proximal stabilization and coordinated motor control [10, 33]. According to contemporary motor control theory, distal precision is optimized when proximal segments provide stable yet adaptable support, reflecting principles of structured variability and hierarchical control within the motor system [31]. Evidence from postural control and spinal motor behavior research further demonstrates that adaptations in trunk and paraspinal muscle coordination influence movement efficiency and control strategy [32, 34]. Improvements in deep cervical, abdominal, and scapular stabilizers therefore extend beyond injury prevention. They reflect enhancement of foundational motor control systems that underpin technical execution and sustained performance capacity [10].

The findings align with the conceptual framework of physical literacy, which emphasizes competence, confidence, and knowledge in movement as lifelong capacities [35]. Within performing arts education, physical literacy should not be viewed as supplementary to artistic training but as enabling substrates for sustainable performance [36]. By demonstrating that structured neuromuscular conditioning can improve postural control within curriculum-compatible formats, this study supports pedagogical shifts from reactive injury management towards proactive motor competence development.

In this sense, the contribution of the study is not limited to musculoskeletal health results. It also provides empirical support for embedding structured movement education into the theoretical foundations of performing arts training [33].

Limitations of the Study and Future Research Directions

This study is limited by a small sample size (N = 26, 100%) and the homogeneity of the participant group, which included only male students. Gender-specific anatomical and hormonal factors may influence injury risk, particularly in the neck and shoulder region, and should be explored in future research. Another limitation is the absence of long-term follow-up. It is unclear whether the improvements observed in muscle function will persist beyond the immediate post-intervention period. Another limitation is the use of standardized clinical grading (0-2 scale) rather than instrument-specific biomechanical or electromyographic (EMG) assessments. This approach ensured feasibility and applicability within educational settings. More objective measures such as surface EMG or motion capture could provide deeper insight into neuromuscular coordination during actual performance.

Future research should adopt multi-institutional designs with larger, more diverse samples, including female students and various instrumental specializations. Given that different instruments impose different biomechanical demands, future research should tailor interventions to specific instrumental families. Interdisciplinary collaborations across physiotherapy, performing arts, and psychology may yield comprehensive models that combine physical, emotional, and cognitive strategies for enhancing performance resilience.

Conclusions

The results of this study confirm that short-term, structured physical intervention significantly improves ($p < 0.01$) the function of key postural muscles, particularly the deep neck flexors, musculus abdominis, and lower scapular stabilizers, in male performing arts students.

The results reinforce the value of preventive strategies that combine diagnostic assessments, mobility exercises, core strengthening, and ergonomic education in addressing the early stages of muscular weakening among musicians. The study demonstrates that performance-related musculoskeletal health can be improved through minimal time investment (2 sessions/week/30 minutes) over a six-week period, making this model both efficient and scalable.

The results suggest that structured neuromuscular interventions should be considered a foundational component of music education, particularly given the high prevalence of PRMDs in this demographic. This research contributes to a growing body of evidence advocating systemic change in university and performing arts training.

Its implications extend beyond injury prevention toward the promotion of lifelong physical literacy and sustainable artistic practice.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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