Comparative effects of functional and traditional exercise training on thoracic kyphosis in 19–22 years old young adults

Efectos comparativos del entrenamiento funcional y tradicional sobre la cifosis torácica en adultos jóvenes de 19 a 22 años

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Abstract

Introduction: Thoracic kyphosis refers to the natural curvature of the upper spine, influenced by vertebral structure, intervertebral discs, and paraspinal muscle strength. Excessive curvature can impair posture, reduce mobility, and negatively affect quality of life.
Objective: The main objective of this study was to compare the impact of functional versus traditional exercise programs on postural thoracic kyphosis in young adults aged 19–22 years.
Methodology: Forty-five participants (21 females and 24 males) were randomly assigned to either a functional training group (core and multi-planar exercises) or a traditional training group (basic strength training). Both groups followed a 12-week program, three sessions per week. Posture was assessed using the Posture Screen Mobile application, and thoracic curvature was quantified with the Cobb angle method.
Results: After the intervention, both groups showed improvements: 3.5° in the functional training group and 1.6° in the traditional training group.
Discussion: Repeated-measures ANOVA ($F(1, 44) = 21.624$, $p < 0.0005$) confirmed a significant effect across time, with greater improvements observed in the functional training group. Conclusions: Findings suggest that functional exercise training is more effective than traditional approaches in reducing thoracic kyphosis in young adults.

Keywords

Functional training, traditional training, thoracic kyphosis, young adults.

Resumen

Introducción: La cifosis torácica se refiere a la curvatura natural de la columna superior, influenciada por la estructura vertebral, los discos intervertebrales y la fuerza muscular paraespinal. La curvatura excesiva puede perjudicar la postura, reducir la movilidad y afectar negativamente la calidad de vida.
Objetivo: El objetivo principal de este estudio fue comparar el impacto de los programas de ejercicio funcional versus tradicional en la cifosis torácica postural en adultos jóvenes de 19 a 22 años.
Metodología: Cuarenta y cinco participantes (21 mujeres y 24 hombres) fueron asignados aleatoriamente a un grupo de entrenamiento funcional (ejercicios de core y multiplanares) o a un grupo de entrenamiento tradicional (entrenamiento de fuerza básico). Ambos grupos siguieron un programa de 12 semanas, tres sesiones por semana. La postura se evaluó utilizando la aplicación Posture Screen Mobile y la curvatura torácica se cuantificó con el método del ángulo de Cobb.
Resultados: Después de la intervención, ambos grupos mostraron mejoras: 3,5° en el grupo de entrenamiento funcional y 1,6° en el grupo de entrenamiento tradicional.
Discusión: El ANOVA de medidas repetidas ($F(1, 44) = 21{,}624$, $p < 0{,}0005$) confirmó un efecto significativo a lo largo del tiempo, observándose mayores mejoras en el grupo de entrenamiento funcional.
Conclusiones: Estos hallazgos sugieren que el entrenamiento funcional es más eficaz que los enfoques tradicionales para reducir la cifosis torácica en adultos jóvenes.

Palabras clave

Adultos jóvenes, cifosis torácica, entrenamiento funcional, entrenamiento tradicional.

Introduction

Kyphosis (plural: kyphoses) refers to the sagittal curvature of the thoracic spine. Kyphosis refers to the curvature of the thoracic spine, resulting from the strength of the paraspinal muscles when standing and the morphology of the vertebrae and intervertebral discs. An anomalous curvature of the spine has been associated with muscle weakness, resulting in diminished mobility, back pain, compromised postural stability, difficulty to maintain an upright position, and a worse quality of life (Çelenay & Kaya, 2018). Significant deviations from ideal posture are thought to adversely affect the appearance and functionality of muscles, perhaps leading to neurological or clinical disorders (Hrysomallis & Goodman, 2001). Suboptimal posture patterns have been shown to diminish the spine's capacity to perceive, sustain, and modify neutral postures (Edmondston et al., 2007). Inadequate postural awareness has been linked to habitual postural changes that elevate load on supporting systems (Edmondston et al., 2007). A kyphotic curve develops in the thoracic and sacral regions, whilst a lordotic curve occurs in the cervical and lumbar areas, constituting the normal spinal curvature in the sagittal plane. Increased thoracic kyphosis is a deformity that may arise from spinal misalignment in individuals of all ages (Bansal et al., 2014; Brzęk et al., 2017; Feng et al., 2017). Conversely, thoracic hyper-kyphosis, or excessive curvature, is characterized by a kyphotic angle of the thoracic spine in the sagittal plane above 40° (Macagno & O'Brien, 2006). Thoracic kyphosis angles ranging from 45° to 50° are designated as postural kyphosis, increased kyphosis, or hyper-kyphosis (Hertling & Kessler, 2005). The standard range for thoracic kyphosis angles in the spine is 20 to 40 degrees. Thoracic hyper-kyphosis may induce a compensatory movement pattern that misaligns the spine's normal curvature, potentially causing musculoskeletal issues such as back discomfort and dysfunction (Nault et al., 2002). Chronic stress on the cervical vertebrae has been linked to an augmentation of the kyphotic curve and misalignment of the cervical curve, including hyperflexion of the lower cervical area and hyperextension of the upper cervical region, potentially resulting in forward head position (Quek et al., 2013). Hyper-kyphosis may significantly adversely affect an individual's quality of life, physical activity, and general health (Huang et al., 2006; Kado et al., 2012). Notwithstanding the adverse consequences of kyphosis on an individual's health, physical functionality, and overall quality of life, there exists no established protocol for rectifying the disease (Feng et al., 2017). Age-related elevations in kyphosis include a kyphosis angle of around 25° (range 20-29°) in adolescents and young adults, and roughly 38.5° (range 35°-42°) in those over 65 (Koelé et al., 2020; Zappalà et al., 2021). Although variations may exist based on ethnicity, no discernible gender preference seems to be present (Zappalà et al., 2021). No consensus exists about the threshold for hyper-kyphosis; nevertheless, it is often accepted that a kyphosis angle over 40° indicates the condition (Koelé et al., 2020; Zappalà et al., 2021). The predominant method used to assess kyphosis is the Cobb angle technique (Koelé et al., 2020; Sadiqi et al., 2016). The angle between the superior endplate of T4 and the inferior endplate of T12 is assessed on an unsupported erect lateral projection (Koele et al., 2020). A Cobb angle ranging from 20° to 40° measured between T2 and T12 is considered typical kyphosis (Perriman et al., 2010; Goh et al., 2000). The Cobb angle approach has a variation of 3-5° and demonstrates inter- and intra-observer discrepancies (Zappalà et al., 2021); it may amplify kyphosis in the presence of associated vertebral endplate anomalies (Twomey, 1992). Elevated kyphotic angles are recorded when measurements are taken above the T4 level (Sadiqi et al., 2016). Interventions and adjustments for kyphosis and hyper-kyphosis anomalies include manual treatment (Bennell et al., 2000), postural re-education, the use of orthoses and tape (Sinaki et al., 2003), as well as therapeutic and surgical exercises (Carter, 2001; Seidi et al., 2014). Physicians sometimes recommend exercise programs to address kyphosis, and exercise therapy is a common approach in this context (Hrysomallis & Goodman, 2001; Katzman et al., 2017; Kamali et al., 2016). Recent randomized studies demonstrate that systematic corrective exercise regimens diminish the thoracic kyphosis angle in adolescents and young adults. Multi-faceted programs including thoracic extension strengthening, scapular stability, and postural perception training shown superior improvements relative to thoracic-only approaches (Elpeze & Usgu, 2022). A 2025 randomized trial comparing two corrective approaches likewise reported meaningful reductions in kyphosis angle after short-term exercise interventions (Mokhtaran et al., 2025). Conventional training methods mostly included machine-based exercises, primarily uniaxial, including Smith machine squats, leg curls, and seated rows, in conjunction with treadmill warm-ups. Conversely, functional training methods mostly included multi-joint movements with free weights, resistance bands, kettlebells, and suspension straps (Beck et al., 2025). Functional training, rooted in rehabilitation, seeks to develop movement patterns pertinent to everyday activities, whereas traditional training adheres to systematic load manipulation principles to augment muscle strength (Beck et al., 2025). The findings of research by Pedraza-Ricra et al. (2025) indicated a substantial correlation between spinal impairment and many indicators, including the endomorphic component of somatotype, adiposity percentage, and muscle mass %. A higher propensity to build body fat and increase weight correlates with a decreased inclination for a less prominent lumbar curvature. This would illustrate that endomorphism does not inherently rectify postural problems like other body types do (Pedraza-Ricra et al., 2025). A study by Muñoz et al. (2023) revealed a correlation between specific body composition factors and somatotype with dynamic postural balance performance in young basketball players. In contrast, muscle mass had a positive connection with postural balance ability alone in the anterior direction of the evaluation. The endomorph and ectomorph somatotypes influence the anterior reach of dynamic postural balance adversely and favourably, respectively (Muñoz et al., 2023). A study conducted over four weeks, focusing on a series of exercises designed to enhance relaxation during Physical Education sessions, emphasized lumbar muscle development and spinal stability and alignment. The findings indicated significant differences between initial and subsequent assessments in two metrics of spinal alignment; however, no alterations were noted in evaluations of spinal stability and electromyography (Ruiz et al., 2024). Properly executed exercises may provide several advantages, particularly when the objective is to enhance back muscular strength and spinal flexibility, alongside activities aimed at improving spinal alignment. This is due to the fact that engaging in physical workouts is a more proactive approach for individuals to take charge of their health compared to alternative therapeutic techniques (Feng et al., 2017). Moreover, prior studies have shown that corrective exercises, including resistance training, stretching, and postural guidance, correlate with a reduction in the kyphosis angle and an enhancement in thoracic posture (Katzman et al., 2017; Szucs et al., 2018). Six-week neuromuscular training research demonstrated enhancements in dynamic postural balance and proprioception among female basketball players with ankle functional instability (Vásquez-Orellana et al., 2022). The research by Verdugo et al. (2024) used a training regimen consisting of targeted core workouts performed fortnightly over a duration of four weeks. The findings demonstrated that, while there were no significant changes in functioning, the experimental group showed a notable decrease in kyphosis ($p=0.016$) and lordosis ($p=0.011$). The results suggest that a fundamental training program may improve posture and reduce pain in college women with low back discomfort. Significant improvements in postural stability were found following the 16-session intervention were participants demonstrated clear improvements in postural stability, especially in the sagittal plane, progressing toward a more upright posture showing that most notable gains occurred in the sagittal plane during bipedal and unipedal stances (Yudho et al., 2025). Research activity concerning corrective and postural exercise programs has intensified during the previous five years, including multi-component corrective, scapular/thoracic strengthening programs. Nevertheless, randomized controlled trial (RCT) data exclusively including 19–22-year-olds is limited; the majority of RCTs concentrate on adolescents (often 10–18 years) or use larger "young adult" categories (usually 18–25 years). This study was designed to examine and compare the effects of two approaches—functional and traditional exercise training—on thoracic kyphosis in young adults aged 19–22 years.

Objectives

The primary aim of this research was to assess the impact of two distinct exercise training modalities (functional and conventional) on postural thoracic kyphosis in individuals aged 19 to 22 years.

Methods

Participants

The participants selected for this research were students from the "Faculty of Physical Activity and Recreation" at the "Sports University of Tirana". A total of 45 people aged 19 to 22 years participated in this research (21 females and 24 males). They were randomly assigned to the intervention group (functional training) and the control group (conventional exercise training). All experiments were conducted at the Biomechanical Laboratory at the Sports University of Tirana. Before the posture assessment, participants were directed to wear comfortable attire (shorts and a blouse) and, during the process, to remove their shoes and adopt an anatomical position with their backs in a neutral alignment while maintaining a composed, relaxed stance. We used the PostureScreen Mobile application (PostureCo, Inc., 2013) to assess postural thoracic kyphosis. This application has been utilized in previous research to evaluate posture assessment reliability and validity (Hopkins et al., 2019; Szucs & Brown, 2018). The software analyzes two or four photographs of each participant to calculate posture-related variables based on digitized anatomical landmarks. Images were captured using the device's integrated camera from the left and right views (sagittal plane) as well as from the anterior and posterior views (coronal plane). When the tablet is level, the app's target-like display illuminates green, enabling you to capture a photograph. This ensures that each image is taken at a consistent level and angle. For this investigation, we have only chosen the posture displacement data of the right and left lateral views (Lateral angulation°) and compared them before and after the exercise intervention. The Cobb angle classification method was used for the assessment of posture (postural thoracic kyphosis) (Zappalà et al., 2021; Ulmar et al., 2010). A line drawn between the superior endplate of T4 and the inferior endplate of T12 determines the Cobb angle. The Cobb angle may be determined at the intersection of these two lines.

Inclusion Criteria

- Age between 19 and 22 years
- Both male and female participants
- Ability to perform exercise workloads safely

Exclusion Criteria

- Musculoskeletal injuries or trauma
- Recent illness or surgical procedures

Intervention Programs

Both groups participated in structured training sessions three times per week for 12 weeks. Training volume and intensity were matched across groups to ensure comparable workloads.

Functional Training Group (Experimental), weekly training sessions example:

- Weekly Functional Training Program
- Warm-up: 10 min (bike/treadmill)
- Mobility & Postural Prep: 10 min
- Functional/Core Training: 30 min
- Cool-down: 10 min (kyphosis-focused)

Table 1. Monday: Postural Activation + Core Stability (Kyphosis emphasis: scapular control & thoracic extension)

Phase	Exercise	Focus	Volume / Time
Mobility	Foam Roller Thoracic Extension	Thoracic extension	2×10
Mobility	Wall Angels	Posture, scapula	2×12
Activation	Resistance Band Pull-Apart	Upper-back activation	2×15
Core	High Plank (Bench)	Anti-extension	30–45 sec
Core	Forearm Plank	Core stability	30–45 sec
Stability	3-Point Plank	Anti-rotation	8–12 / side
Stability	Bench w/ Leg Raise	Pelvic control	8–12
Dynamic Core	Superman Plank	Posterior chain	8–12
Stability	2-Point Bench	Advanced control	6–10
Postural Strength	Prone Y-Raise	Lower traps	2×12

Table 2. Wednesday: Lateral Core + Scapular Stability (Kyphosis emphasis: lateral chain + upper-back endurance)

Phase	Exercise	Focus	Volume / Time
Mobility	Cat–Cow (Thoracic focus)	Spine mobility	2 min
Mobility	Quadruped Thoracic Rotation	Upper-back mobility	2×8 / side
Activation	Scapular Push-Ups	Serratus anterior	2×15
Core	Lateral Plank	Lateral core	20–30 sec
Core	Lateral Plank (Leg Lift)	Glute-med	Same duration
Dynamic	Lateral Hip Raises	Core + hips	8–12
Core	Side Bench (High Plank)	Shoulder stability	20–30 sec
Stability	Side Bench w/ Hip Raise	Control	8–12
Postural Strength	Band Face Pulls	Scapular retraction	2×15
Postural Strength	Reverse Snow Angels (Prone)	Upper-back endurance	2×12

Table 3. Friday: Thoracic Mobility + Rotational Core (Kyphosis emphasis: controlled rotation & extension)

Phase	Exercise	Focus	Volume / Time
Warm-up	Rowing Machine / Bike	Upper-body warm-up	10 min
Mobility	Seated Thoracic Extension Reach	Extension	2×10
Mobility	Foam Roller Open Books	Rotation	2×8 / side
Activation	Resistance Band Rows	Scapular control	2×15
Core	Supine Roll-Out (Swiss Ball + Plate)	Anti-rotation	5 / side
Core	Woodchop (Standing Plate)	Rotational power	8–12
Core	Grave Diggers (Plank + DB Raise)	Shoulder stability	8–12
Stability	Half-Kneeling Pallof Press	Anti-rotation	10–12
Strength	Incline Push-Up (Chest open)	Postural pushing	10–12
Postural Strength	Prone T-Raise	Mid-traps	2×12

Cool-down (10 min – Kyphosis-Focused)

- Doorway Chest Stretch – 60 sec
- Lat Stretch (Overhead or Wall) – 60 sec
- Prone Press-Up (Cobra) – 2×10 slow reps
- Supine Breathing (Diaphragmatic) – 2–3 min
- Upper Trapezius Stretch for neck relief (45 sec / side)
- Lat Stretch for thoracic mobility (60 sec)
- Diaphragmatic Breathing for posture (2–3 min)

Traditional Training Group (Control)

The exercise program of the traditional fitness training group consisted of:

Participants in the traditional fitness training group completed a 12-week supervised resistance training program designed to improve muscular fitness while emphasizing thoracic kyphosis–related postural correction. The intervention was conducted three times per week on non-consecutive days, with each session lasting approximately 60 minutes. Each training session consisted of four standardized components: (1) general warm-up (5–8 min), (2) general and thoracic-specific mobility and stretching (~10 min), (3) resistance and corrective training (~40 min), and (4) cool-down stretching (~5 min). The resistance training program employed a linear progression model over 12 weeks. During weeks 1–4, participants trained at 55–65% of one-repetition maximum (1RM) using 3 sets of 12 repetitions, emphasizing proper technique, neutral spinal alignment, and postural awareness. During weeks 5–8, training intensity increased to 65–75% 1RM with 3 sets of 10 repetitions, focusing on improved posterior-chain engagement and scapular control. In the final phase (weeks 9–12), participants trained at 75–85% 1RM using 3 sets of 8 repetitions, while maintaining thoracic extension and upright posture under higher external loads. Rest intervals ranged from 60 to 120 seconds, depending on training intensity and exercise complexity.

Table 4. Weekly Exercise Content (Applied Each Training Week)

Day	Muscle Groups	Exercises
Monday	Legs & Shoulders	Squat, Leg Press, Leg Extension, Leg Curl, Calf Raises, Shoulder Press, Bent-Over Raise
	Postural/Corrective	Face Pulls, Prone Y-Raise
Wednesday	Chest & Biceps/Forearms	Bench Press, Incline Press, Fly, Barbell Curl, Hammer Curl, Reverse Curl
	Postural/Corrective	Reverse Pec Deck / Band Pull-Apart, Wall Angels
Friday	Back, Triceps, Core	Pull-Ups / Lat Pulldown, Barbell Row, Machine Row, Deadlift, Pushdown, Lying Extension, Seated Press

Table 5. Detailed 1–12 Week Progression Model

Week	Intensity (%1RM)	Sets × Reps	Rest (s)	Postural Emphasis
1	55%	3×12	60–75	Technique, spinal alignment
2	55–60%	3×12	60–75	Scapular control awareness
3	60%	3×12	60–75	Thoracic extension cueing
4	60–65%	3×12	60–90	Improved movement consistency
5	65%	3×10	75–90	Reduced shoulder protraction
6	65–70%	3×10	75–90	Posterior-chain engagement
7	70%	3×10	90	Postural endurance
8	70–75%	3×10	90	Controlled chest loading
9	75%	3×8	90–120	Thoracic extension under load
10	75–80%	3×8	90–120	Scapular strength dominance
11	80–85%	3×8	120	Maintained upright posture
12	80–85%	3×8	120	Peak postural stability

Data analysis

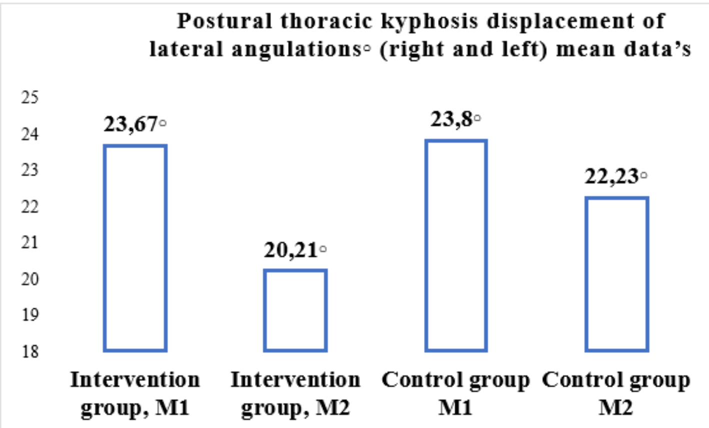
Data were analysed using IBM SPSS Statistics 26. Descriptive statistics were first calculated, followed by assessments of data distribution and variance homogeneity. The main inferential tests included:

- T-tests for within-group comparisons.
- Repeated-measures ANOVA with Greenhouse-Geisser correction to evaluate changes between pre- and post-intervention measurements.

Results

Postural thoracic kyphosis measurement results:

Figure 1. Postural thoracic kyphosis displacement of lateral Angulations◦ (right and left) mean data (M1 = Measurement 1, M2 =Measurement 2).



Following the intervention programs, the second assessment revealed a notable enhancement in posture for both groups, with the "intervention group" (functional training program) exhibiting an improvement of approximately 3.5°, and the "control group" (traditional training program) demonstrating an enhancement of approximately 1.6° (See Figure 1).

Figure 2. Data distribution by groups for "Postural thoracic kyphosis displacement of lateral Angulations" in the first measurement (M1).

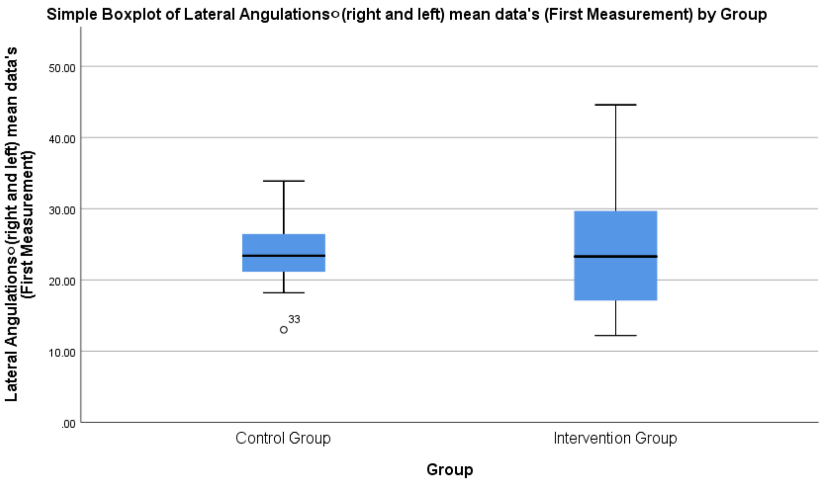
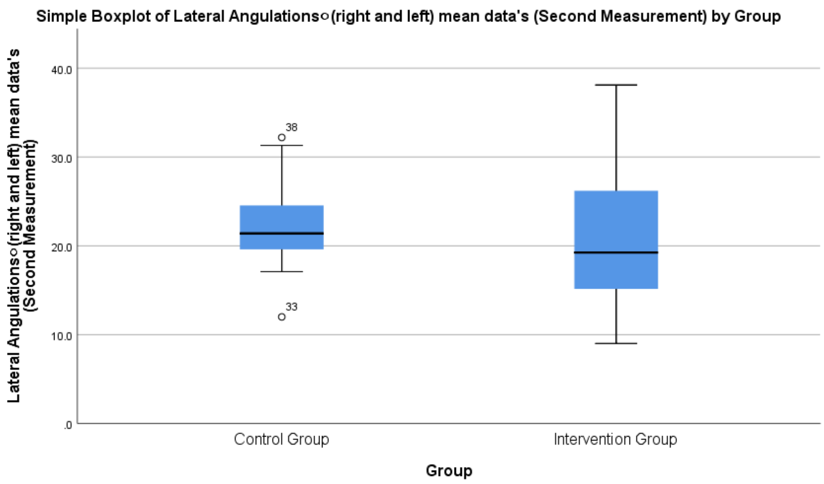


Figure 3. Data distribution by groups for "Postural thoracic kyphosis displacement of lateral Angulations" in the second measurement (M2).



Postural Thoracic Kyphosis Outcomes

Descriptive and inferential analyses demonstrated improvements in postural thoracic kyphosis in both the functional training (experimental) and traditional training (control) groups following the 12-week intervention. At baseline, participants in both groups presented thoracic kyphosis angles within normative limits (20–40°), indicating the absence of pathological hyperkyphosis; however, mild postural deviations were evident, consistent with habitual postural adaptations commonly observed in young adult populations.

Following the intervention, the functional training group exhibited a mean reduction of 3.5° in thoracic kyphosis displacement, whereas the traditional training group demonstrated a smaller mean reduction of 1.6°. These findings indicate that although both interventions contributed to postural improvement, the magnitude of change was notably greater in the functional training group (Figure 1).

Normality testing using the Kolmogorov–Smirnov test confirmed that thoracic kyphosis displacement values approximated a normal distribution across both measurement points. Levene's test further confirmed homogeneity of variance between groups, satisfying the assumptions required for parametric analysis. Visual inspection of data distributions (Figures 2 and 3) supported these findings.

A repeated-measures ANOVA with Greenhouse–Geisser correction revealed a statistically significant main effect of time on thoracic kyphosis displacement ($F(1, 44) = 21.624$, $p < .0005$), indicating that both training programs effectively improved postural alignment over the 12-week period. Moreover, the greater reduction observed in the functional training group suggests a superior adaptive response relative to traditional resistance training alone.

Discussion

The purpose of this study was to compare the effects of functional and traditional exercise training on postural thoracic kyphosis in young adults aged 19–22 years. The primary finding was that both training modalities produced statistically significant improvements, with functional training eliciting a substantially greater reduction in thoracic kyphosis. The superior outcomes observed in the functional training group can be attributed to the multi-planar, multi-segmental, and core-integrated nature of the exercises employed. Functional training emphasizes coordinated movement patterns, scapular stabilization, thoracic extension, and neuromuscular control—elements that are critically involved in postural regulation (Beck et al., 2025; Feng et al., 2017). In contrast, traditional resistance training primarily targets isolated muscle groups through uni-planar movements, which may not sufficiently address the neuromuscular and postural components required for spinal realignment (Hrysomallis & Goodman, 2001). These findings are consistent with previous research demonstrating that comprehensive corrective exercise programs are more effective in reducing thoracic kyphosis than localized or strength-only interventions (Elpeze & Usgu, 2022; Kamali et al., 2016). Katzman et al. (2017) similarly reported that interventions combining postural training with targeted strengthening of the thoracic extensors and scapular stabilizers yielded significant improvements in spinal alignment.

The observed improvement of 3.5° in the functional training group is clinically meaningful when considered alongside the inherent measurement variability of the Cobb angle (±3–5°) (Zappalà et al., 2021). Given the young age of the participants and the absence of structural deformities, even modest angular reductions may reflect meaningful neuromuscular adaptations and improved postural awareness rather than structural spinal changes. The traditional training group also demonstrated improvement, albeit to a lesser extent. This suggests that general resistance training may indirectly influence posture through increased muscular strength and endurance, particularly in the posterior chain (Feng et al., 2017). However, the smaller magnitude of change supports the notion that traditional programs alone may be insufficient for optimal postural correction, especially when not explicitly designed to address thoracic mobility and scapular control. Importantly, the present findings align with recent evidence highlighting the role of core stability, thoracic mobility, and scapular muscle endurance in postural health (Verdugo et al., 2024; Yudho et al., 2025). Functional training inherently integrates these components, thereby promoting adaptations that extend beyond isolated strength gains.

This study contributes to the existing literature by addressing a narrow age range (19–22 years) that is underrepresented in randomized controlled trials. Most previous investigations have focused on adolescents or broader young adult cohorts, limiting age-specific applicability (Koelé et al., 2020). The present results therefore provide valuable evidence for exercise prescription in university-aged populations.

Conclusions

This study demonstrated that both functional and traditional exercise training programs are effective in improving postural thoracic kyphosis in young adults aged 19–22 years. However, **f**unctional training produced significantly greater improvements in thoracic alignment compared to traditional resistance training. Although none of the participants presented pathological thoracic hyperkyphosis, measurable postural deviations were evident at baseline. Following 12 weeks of intervention, the functional training group achieved a mean reduction of 3.5° in thoracic kyphosis, whereas the traditional training group showed a smaller reduction of 1.6°. These findings suggest that functional training offers superior postural benefits, likely due to its emphasis on multi-planar movement, core stabilization, and scapulothoracic control. Given the relatively short intervention period and the young, non-clinical population, the magnitude of improvement observed is considered meaningful. However, it remains unclear whether these adaptations would be sustained over longer periods without continued training. Future research should explore long-term follow-up effects, incorporate biomechanical and neuromuscular outcome measures, and examine dose–response relationships across different training intensities. In conclusion, functional exercise training appears to be a more effective and comprehensive approach than traditional resistance training for improving postural thoracic kyphosis in young adults. These findings support the integration of functional training principles into preventive and corrective exercise programs aimed at optimizing postural health in university-aged populations.

Recommendations

Based on the findings of the present study, several practical, methodological, and research-oriented recommendations can be proposed for exercise professionals, educators, clinicians, and researchers working with young adult populations. From a practical perspective, exercise practitioners should consider integrating functional training principles into standard fitness and corrective exercise programs aimed at improving postural alignment, particularly thoracic kyphosis. The results indicate that multi-planar, core-integrated exercises emphasizing thoracic extension, scapular stabilization, and neuromuscular control are more effective than traditional resistance training alone. Fitness professionals working in university gyms, sports clubs, and wellness centers are therefore encouraged to include exercises such as plank variations, anti-rotation movements, scapular retraction drills, and thoracic mobility exercises within routine training sessions. Even when the primary goal is general strength development, embedding postural components may enhance musculoskeletal health and reduce the risk of long-term postural dysfunction (Katzman et al., 2017; Feng et al., 2017).

In educational settings, particularly within faculties of physical activity, sports science, and health sciences, structured functional training modules should be incorporated into practical curricula. Young adults often spend prolonged periods in sedentary positions due to academic demands, which may contribute to postural deviations even in the absence of clinical pathology. Early exposure to postural education and functional movement training may promote long-term postural awareness and healthier movement behaviors. Universities are therefore encouraged to adopt preventive exercise strategies as part of student wellness programs. From a **c**linical and preventive standpoint, although the participants in this study did not present with pathological thoracic hyperkyphosis, the observed postural improvements suggest that early intervention can yield meaningful neuromuscular adaptations. Clinicians and rehabilitation specialists may consider functional training as a first-line, non-invasive intervention for individuals with mild to moderate postural kyphosis before more restrictive approaches, such as bracing or passive therapies, are considered. Functional training's emphasis on active participation may also improve adherence and long-term engagement compared to more passive treatment modalities (Hrysomallis & Goodman, 2001). With regard to future research, longitudinal studies with extended follow-up periods are recommended to determine whether the postural improvements observed in this study are maintained after the cessation of structured training. Additionally, future investigations should incorporate **l**arger sample sizes, sex-specific analyses, and biomechanical assessments (e.g., electromyography, spinal mobility testing) to further elucidate the mechanisms underlying postural change. Comparing hybrid training models that combine traditional resistance training with functional and corrective components may also provide valuable insight into optimal program design. Finally, researchers are encouraged to expand investigations into different populations, including sedentary students, athletes, and individuals with clinically diagnosed hyperkyphosis, to improve generalizability. Standardizing assessment protocols and intervention reporting will further strengthen the evidence base and support the development of clear, evidence-based exercise guidelines for thoracic kyphosis management.

Study limitations

The limited sample size and narrow age range (19–22 years) constrain the applicability of the findings to wider or clinical groups. The 12-week intervention time, although adequate for eliciting neuromuscular adaptations, may be insufficient to ascertain enduring or structural alterations in thoracic spinal curvature, especially without post-intervention follow-up evaluations.

Third, individuals did not exhibit pathological thoracic hyperkyphosis at baseline, which may have limited the extent of visible postural improvement. The lack of blinding and restricted oversight of participants' physical activity beyond the intervention sessions may have resulted in measurement and performance bias. Despite these limitations, the study presents significant preliminary data for the efficacy of functional training in improving thoracic posture among young people and establishes a basis for forthcoming controlled and longitudinal research.

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