Original Article

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Physiotherapy Section

Effect of Home-based Exercise Program on Postural Kyphosis in Adolescent Population: An Interventional Study

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ABSTRACT

Introduction: With the increasing prevalence of musculoskeletal issues like thoracic kyphosis, caused by inappropriate modern lifestyle habits, the aim of this study is to assess whether exercise can improve postural alignment and maintain these improvements over time.

Aim: This study investigates the effects of a Home Exercise Program (HEP) on the Thoracic Kyphosis Angle (TKA) in adolescents aged 10 to 18 years.

Materials and Methods: This is an interventional study observing the effect of a four-week home exercise program on postural kyphosis in adolescents, conducted at KM Patel Institute of Physiotherapy in Karamsad, Gujarat, India. The study duration was from January 2024 to March 2025, during which a total of 84 participants were screened. Out of these, 44 were recruited into a single group according to the inclusion criteria, with a TKA (θ)>40°, from various local schools in the Anand district. Participants were preassessed (TKA (θ)-A) and then given a four-week HEP. Postintervention, participants were reassessed (TKA (θ)-B), and after four weeks of cessation of the intervention, a final assessment (TKA (θ)-C) was conducted. Statistical analysis was performed using paired t-tests (p-value <0.05) in Statistics and Data (STATA) version 14.2.

Results: The study found that thoracic kyphosis is slightly more prevalent in males (52%) than in females (48%). There were statistically significant improvements (p<0.05) in TKA, indicating the effectiveness of the exercise program. After the cessation of exercise for another four weeks, no significant difference was found in TKA (p>0.05), which shows the retention effect of exercise after four weeks of inactivity.

Conclusion: The study concluded that the given home-based exercise program is effective in improving thoracic kyphosis and maintaining postural alignment over time, even four weeks after discontinuation. However, intermittent exercise can still be beneficial to prevent further postural deviations.

Keywords: Flexi-curve ruler, Postural correction exercise, School children, Thoracic kyphosis

INTRODUCTION

Modern lifestyles, characterised by higher levels of technology use, sedentary behavior, and the strain of heavy backpacks, have led to a growing incidence of postural issues in children and adolescents. Prolonged use of electronic devices, often associated with incorrect posturing, along with weak core and back muscles, causes muscle imbalances and postural alterations (e.g., forward head posture, rounded shoulders), as well as spinal deformities (e.g., thoracic kyphosis, lumbar lordosis) [1,2]. If left unaddressed, these problems can have lasting harmful effects on children's physical health, potentially resulting in chronic pain and impacting their emotional and developmental progress during vital growth phases [3].

Thoracic kyphosis, characterised by an outwardly concave curvature of the thoracic spine, often results in a hunchback or humpback appearance [4]. Although it can affect the cervical spine, it more often impacts the thoracic or thoracolumbar regions [5]. The Thoracic Kyphosis Angle (TKA) is characterised by values between 20° and 40°. Hyper-kyphosis is identified when this angle surpasses 40° [6]. Epidemiological studies indicate heterogeneous prevalence rates of hyper-kyphosis in adolescents, ranging from 7.8% to 58%, which most likely reflects methodological differences and demographic variations in the studied populations [7,8]. Known risk factors include, among others, a lack of physical exercise, sedentary behavior, excessive computer use, psychological stress, and poor nutrition. These factors result in physiological changes that promote bad posture [9].

Progressive slumping posture can lead to characteristic muscle imbalances [10]. On the other hand, the pectoral muscles of the upper limb, such as the upper trapezius and pectoralis major, and the cervical flexors become tight, while the erector spinae and lower trapezius muscles get loose and elongated [11]. The outcome of this muscle dysfunction can exacerbate thoracic kyphosis, in addition to causing pain, reducing spinal stability, and increasing the likelihood of developing other musculoskeletal disorders. Early detection and treatment are necessary to avoid adverse effects [12].

Successful evaluation of TKA is essential for proper diagnosis and treatment monitoring. Multiple measurement methods are available, including both radiographic and clinical techniques. Among clinical instruments, the flexi-curve ruler and Debrunner kyphometer have been proven to have good reliability and validity, making them suitable for use in clinical practice and research [13,14].

Many studies have investigated the effects of corrective exercises and postural retraining on improving TKA [15-17]. These methods typically involve strengthening underactive muscles, stretching overactive muscles, and improving postural awareness [17]. Although there have been descriptions of short-term improvements in TKA, a significant gap remains regarding the long-term efficacy of these programs [18]. Whether changes in TKA due to exercise persist after the intervention, or whether the angle deteriorates, needs further clarification. Understanding the long-term impact of exercise is crucial for developing effective management strategies for adolescent postural kyphosis.

Consequently, this study aims to explore the long-term effects of exercise interventions on enhancing postural kyphosis in adolescents aged 10 to 18 years. This research will provide important information about the maintenance of exercise-induced TKA improvements and guide evidence-based recommendations for addressing this common postural concern.

MATERIALS AND METHODS

The present interventional study included a pre-test, post-test, and follow-up design. The study was conducted at K M Patel Institute of Physiotherapy, Bhaikaka University, Karamsad, Gujarat, India, over a duration from January 2024 to March 2025. Before commencing the procedure, ethical approval was obtained from the Institutional Ethical Committee (IEC) (IEC/BU/151/Faculty/14/ 191/2024). Participants were recruited from local schools in the Anand district using purposive sampling based on inclusion and exclusion criteria. Informed written consent was obtained from the school principal and parents of all children before screening and inclusion in the study in accordance with the Helsinki Declaration of 1964, revised in 2013.

Sample size calculation: Sample size was calculated using a t-test (one-sample case) with an effect size of 0.05, an alpha error probability of 0.05, and a power (1-beta error probability) of 0.90. The calculated sample size was 36 (G*Power 3.1.2). This calculation was based on a thoracic kyphosis prevalence of 52% reported in previous studies [15]. However, 44 participants were ultimately recruited and analysed.

Inclusion and Exclusion criteria: The present study included children aged 10 to 18 years who presented with a thoracic kyphosis angle greater than 40 degrees. Only healthy children, free from any pre-diagnosed co-morbidities, were considered for participation. Participants were excluded if they presented with any spinal deformities or had congenital anomalies that affected spine and trunk mobility. Individuals currently undergoing medical treatment for any chest or spine condition were also excluded.

Study Procedure

A total of 84 participants were screened, and 44 met the inclusion criteria, resulting in a prevalence of 53%. The TKA was measured using a flexi-curve ruler (intra-rater reliability: 0.87; inter-rater reliability: 0.94) [13] and calculated using an arctan calculator (online software) [19]. The four week intervention consisted of supervised instruction and demonstration of a home exercise program to be performed twice daily. Participants received detailed instructions and observed the exercise routine demonstrated by the author. Adherence to the program was monitored through weekly follow-up sessions and exercise diaries kept by the author. TKA was reassessed at four weeks, TKA (θ-B) to evaluate the immediate effect of the intervention compared to baseline TKA (θ-A). Four weeks after the exercise program was discontinued (8 weeks total), a final TKA assessment (θ-C) was conducted to evaluate the maintenance of improvements and any further changes in angles. There were no dropouts in the study.

Measurement of TKA: Thoracic kyphosis angle (θ) was measured using the flexi-curve ruler as follows:

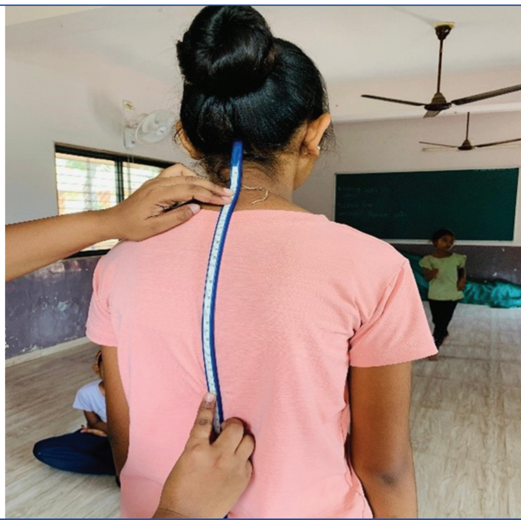
- Position: Have the participant stand. Place the flat side of the flexi-curve on their spine at the C7 vertebra (top of the curve) and mold it along the spine down to the T12 vertebra (bottom of the curve).
- Transfer: Carefully lift the flexi-curve, keeping its shape, and place it on graph paper [Table/Fig-1].
- Trace: Trace the side of the flexi-curve that touched the skin. Mark the C7 and T12 locations on the paper.
- Measure: Measure the height (H) and length (L) of the traced curve.
- Calculate: Use the formula and an arctan calculator [19] to find the thoracic kyphosis angle (TKA-θ).

Formula for calculating TKA (θ) [20]:

Kyphosis Angle (θ)=4 X {arc tan (2H/L)}

Where;

H is the height of the curve (perpendicular to length).



[Table/Fig-1]: TKA measurement using flexi-curve ruler.

L is the length of the curve.

Tailored Intervention Program [Table/Fig-2]: The following exercises were performed six days each week.

- Warm-Up (to be done every day before starting the exercise): Diaphragmatic breathing exercises, Tad asana stretches, arm circles (clockwise and counterclockwise), marching in place (5 repetitions×2 sets).
- Week 1: Chin tucks (sitting), thoracic stretch, pectoral wall stretches, scapular squeezes, thoracic mobility exercises (10 repetitions×2 sets).
- Week 2: Pectoral wall stretches, shoulder shrugging exercises, scapular squeeze exercises, thoracic rotation exercises, wall push-ups (10 repetitions×2 sets).
- Week 3: Horizontal abduction stretches, bridging, T arm raises (prone), W arm raises (prone), Y arm raises (prone) (10 repetitions×2 sets).
- Week 4: Thoracic rotation exercises, child pose stretches, abdominal curls, cat and camel exercises, bird dog exercises (10 repetitions×2 sets).
- Cool Down (to be done every day after completing the exercise for 5 minutes): Diaphragmatic breathing exercise, Tad asana stretch, savasana (5 repetitions×2 sets).

(See supplementary material for the detailed exercise program).

[Table/Fig-2]: Teaching home exercise program to participants.

STATISTICAL ANALYSIS

Data were documented in an Microsoft (MS) Excel spreadsheet, and the analysis was conducted using STATA (14.2) software. Descriptive statistics, including mean {Standard Deviation (SD)} and frequency (%), were computed to illustrate the baseline characteristics of the participants. A paired t-test was utilized to evaluate changes in TKA by comparing TKA-A with TKA-B before and after the intervention. Following a 4-week cessation of exercise, the final follow-up data, TKA-C, were analyzed against TKA-B using a paired t-test. A significance level of less than 0.05 was established to determine statistical significance.

RESULTS

The [Table/Fig-3] shows the baseline characteristics and demographic details of the participants assessed before commencing the exercises. The mean (SD) age of participants was 12.45 (0.72), and the mean BMI was 15.286 (2.77). The mean TKA (θ- A) assessed pre-intervention was 45.375 (3.19). [Table/Fig-4] shows the total number of participants by gender, revealing a higher prevalence among males compared to females. [Table/Fig-5] presents a comparison of the mean and SD of TKA (θ)-A and TKA (θ)-B, indicating a statistically significant difference with a p-value <0.05. [Table/Fig-6] compares the mean and SD of TKA (θ)-B and TKA (θ)-C, showing no statistically significant difference with a p-value >0.05.

Variables	Minimum	Maximum	Mean (SD)
Age (years)	11	14	12.45 (0.72)
Height (cm)	120	160	141.068 (8.39)
Weight (kg)	19.2	46.4	30.677 (7.38)
BMI (kg/m²)	11.1	23	15.286 (2.77)
TKA (θ-A)	41	56.12	45.375 (3.19)

[Table/Fig-3]: Shows the baseline/demographic characteristics of the participants.

Gender	No. of participants (n=44)	Prevalence
Female	21	48%
Male	23	52%

[Table/Fig-4]: Total number of participants as per gender.

TKA (θ)	TKA (θ)-A	TKA (θ)-B	p-value
Mean (SD)	45.37 (3.19)	41.27 (3.83)	0.0001

[Table/Fig-5]: Comparison of Mean and SD of TKA (θ)-A and TKA (θ)-B.

TKA (θ)	TKA (θ)-B	TKA (θ)-C	p-value
Mean (SD)	41.27 (3.83)	41.59 (3.40)	0.2577

[Table/Fig-6]: Comparison of Mean and SD of TKA (θ)-B and TKA (θ)-C.

TKA (θ) was evaluated as the main outcome at three different time points. TKA (θ)-A represents the measurement taken before the intervention, TKA (θ)-B reflects the measurement after four weeks of exercise, and TKA (θ)-C denotes the measurement taken at eight weeks, following four weeks without exercise. When comparing the mean of TKA (θ)-A to the mean of TKA (θ)-B using a paired t-test, the resulting p-value was 0.0001, which is <0.05. This result suggests that a statistically significant difference exists between the TKA values prior to and following four weeks of the home-based exercise program, highlighting the effectiveness of exercise in lowering TKA.

In a similar manner, when conducting a paired t-test to compare the mean of TKA-B with TKA-C, the calculated p-value was 0.2577, which is >0.05, indicating no significant difference between these two measurements. This implies that there is retention or a long-term effect of exercise on thoracic kyphosis even after four weeks of discontinuation of the exercise program.

DISCUSSION

This research examined the prolonged effects of a 4-week HEP on TKA in adolescents aged 10 to 18 years. Our results indicate that a 4-week HEP can lead to statistically significant enhancements in TKA, with these improvements preserved for at least four weeks following the completion of the exercise program. The average TKA at baseline (TKA-A) was measured at 45.37° (±3.19°), categorizing the participants as hyperkyphotic, which aligns with earlier studies highlighting the prevalence of postural issues in this demographic (Dop D et al., 2024; Hanfy HM et al., 2012) [7,16].

This initial measurement also correlates with research noting an increase in kyphosis during pubertal development (Nissinen M, 1993; Willner S and Johnson B, 1991) [21,22]. The reduction in TKA following the 4-week HEP (TKA-B=41.27°±3.83°) supports the efficacy of exercise interventions aimed at improving postural alignment, reflecting findings from other investigations [15,17,23]. The comprehensive corrective exercise program included in the study played a vital role in improving TKA, as described by Elpeze G and Usgu G (2022) [6].

The HEP used in this study (outlined in the supplementary material) consisted of a progressive exercise sequence targeting muscle imbalances linked to kyphosis, which included stretching tight anterior muscles (like the pectoralis major and upper trapezius) and strengthening weakened posterior muscles (such as the lower trapezius and erector spinae) [18].

An essential point of interest for this analysis is the follow-up during the 4-week retention period after HEP cessation at TKA-C (TKA-C = 41.59°±3.40°). The lack of a significant statistical difference between TKA-B and TKA-C (p>0.05) indicates that at least some benefits from the exercise program were gained and did not dissipate immediately after its completion. Currently, there are no previous studies that demonstrate these retention effects of exercise on kyphosis.

This type of retention effect is important from a clinical perspective, as it suggests that modest exercise engagement has the potential to contribute to some long-lasting positive changes in posture. Several sociocultural factors could mediate this retention effect. According to McArdle WD et al., muscle alterations such as increases in myofibrillar protein synthesis, which support muscle hypertrophy, are positive outcomes of strength training [24]. Enhancements in strength and power may facilitate the calibration of postural control and stability, aiding in the maintenance of favorable postural alignment for some time after the cessation of the exercise program.

In addition, Hortobágyi TI et al., have suggested that a large proportion of reasonably fit individuals can retain many benefits of strength training for several weeks after they stop training [25]. While our participants do not fall under the "well-trained" category prior to the study, the 4-week intervention, based on the principle of progressive overload, may have been sufficient to induce some muscle adaptation, aiding in the retention effect. The weekly check-ins and the diaries that required daily entries likely contributed to maintaining proper posture throughout the day and compliance with the exercises, even after the official end of the program. Furthermore, the strong inter-rater reliability of the flexi-curve ruler (0.94) gives greater confidence in the TKA measurements we obtained [13].

Clinical implications: This research provides valuable insights regarding the treatment of postural kyphosis among youth. It indicates that after a four-week HEP, the TKA is significantly decreased, and the positive results appear to sustain for at least four weeks post-treatment. These findings support the consideration of HEP as a simple and cost-effective initial intervention. These exercises can be prescribed directly to individuals and can be performed under supervision, potentially preventing the worsening of kyphosis.

The research also highlights the need to address muscle weaknesses associated with kyphosis through active stretches and exercises, which plays a significant role in formulating HEPs for individuals. The retention effect observed underscores the necessity of integrating exercises into the daily routines of adolescents to achieve lasting improvements in posture.

Clinicians can now use the flexi-curve ruler to accurately measure and document changes in TKA. To enhance effectiveness, it is essential to provide clear instructions for exercises, encourage adherence through strategies such as weekly check-ins and exercise logs, and inform patients and their families about the benefits of good posture and regular physical activity.

Limitation(s)

The study included follow-up assessments after four weeks, and to evaluate long-term effects, further follow-up was also conducted after another four weeks. Thus, additional longer follow-ups may be necessary to justify the long-term effects.

CONCLUSION(S)

The present study provides preliminary evidence demonstrating that a home-based exercise program of four weeks can produce statistically significant changes in the thoracic kyphosis angle in adolescents and has positive influences on retaining the exercise effect for at least four weeks after completing the program. However, due to the study design and other methodological limitations, cautious interpretation is warranted. Additional research employing randomized controlled trials with larger participant samples, objective adherence measures, and longer follow-up periods is needed to confirm these results and provide definitive recommendations for exercise interventions in managing postural kyphosis in adolescents. Although this study offers valuable initial evidence, further research, including randomised controlled trials, is necessary to validate these outcomes, refine HEP protocols, and determine long-term effectiveness. Combining HEPs with other interventions, such as postural education and manual therapy, may provide a more comprehensive approach.

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