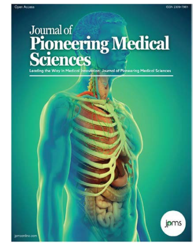

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Comparison of Pilates Mat and Kendall Exercises on Craniovertebral Angle, Pain and Neck Disability among Young Adults with Forward Head Posture: A Pilot Randomized Controlled Trial

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Abstract **Objectives:** Forward Head Posture (FHP) is a common postural deviation among young adults characterised by reduced craniovertebral angle and neck pain. Pilates Mat exercises enhance posture and core stability, whereas Kendall exercises correct postural muscular imbalances through strengthening and stretching. The study was intended to assess the effects of Pilates Mat and Kendall exercises on craniovertebral angle, pain and neck impairment in young adults with FHP. **Methods:** Thirty-four young adults with FHP were randomly assigned to Pilates Mat and Kendall exercise groups. Photogrammetry, the Numeric Pain Rating Scale (NPRS) and the Neck Disability Index (NDI) were used to measure craniovertebral angle, pain intensity and neck disability at baseline, four weeks and eight weeks. **Results:** Baseline parameters were similar between groups ($p>0.05$). All outcome measures (CVA, NPRS, NDI) had significant main effects of time, group and time × group interaction (all $p<0.001$). At T8, the Pilates Mat group had greater improvements compared to the Kendall Exercise group in CVA (MD = 5.06°, 95% CI: 4.16-5.95, $p<0.001$), NPRS (MD = −2.53 points, 95% CI: -3.25 to -1.81, $p<0.001$) and NDI (MD = −13.59 points, 95% CI: −14.51 to −12.66, $p<0.001$). Bonferroni-adjusted comparisons showed substantial improvements in both groups across all time intervals (all $p<0.001$). **Conclusion:** Both Pilates Mat and Kendall exercise improved the craniovertebral angle and reduced pain severity and neck disability among young adults with forward head posture; with greater improvements observed following Pilates Mat Exercise.

Key Words Good Health and Well-being, Forward Head Posture, Kendall Exercise and Pilates Mat Exercise, Young Adults

INTRODUCTION

Proper posture is essential for maintaining musculoskeletal balance and minimising excessive stress on the body. Appropriate postural alignment ensures optimal distribution of mechanical loads, thereby preventing structural abnormalities and musculoskeletal disorders [1,2]. However, sedentary lifestyles, increased screen time and workplace demands have contributed to an increased prevalence of postural misalignments [3]. Forward Head Posture (FHP) is a commonly observed postural abnormality in the sagittal plane [4]. Epidemiological studies have shown that FHP is highly prevalent in many populations, with a prevalence of 63.96% in college students and 73% in adolescents [5,6]. Sedentary adults or those with extended screen time are at greatest risk irrespective of variations in incidence rates by age [7].

FHP is characterised by the forward posture of the head in relation to the cervical spine, causing hyperextension of the upper cervical spine (C1-C3) and increased flexion of the lower cervical spine (C4-C7) and upper thoracic spine [8].

This altered head position shifts the centre of gravity of the head anteriorly, increasing the mechanical stress on the cervical spine and potentially contributing to neck pain, muscle imbalance, altered cervical muscle function and potentially contributing to neck pain, muscle imbalance, altered cervical muscle function and other musculoskeletal impairments [9]. In addition to postural alterations, adaptive muscular imbalances emerge with shortening of the cervical extensors, pectoral muscles and suboccipital muscles and weakening of the deep cervical flexors and scapular retractors. Compensatory activation of the upper trapezius and sternocleidomastoid muscles takes place to support the head and maintain postural stability. These changes affect the normal cervical curve and create abnormal movement patterns and postural dysfunction [10].

FHP has been associated with neck and shoulder pain, myofascial pain syndrome, altered scapular kinematics, respiratory dysfunction, limited cervical range of motion and reduced postural control clinically [11,12]. The severity of FHP is typically measured by the Craniovertebral Angle (CVA), which is defined as the angle between a horizontal line through the spinous process of C7 and the line through C7 and the tragus of the ear [13]. Decreased CVA values have been closely related to neck pain, restriction of cervical movement and postural instability [14]. FHP can be treated with several conservative-oriented treatment procedures, including postural correction exercises, neck stabilisation exercises, scapula stabilisation exercises, standardised strengthening and stretching programs, elastic resistance exercises, Kendall exercises and Pilates Mat exercises [15-17]. Pilates Mat exercises and Kendall postural exercises were selected because both approaches are commonly used to address postural dysfunction but differ in their therapeutic emphasis.

Kendall exercise corrects unstable FHP and readjusts neck position by strengthening deep cervical flexor and shoulder retraction muscles and extending pectoral muscles [18]. In contrast, Pilates Mat corrective exercises are a mind-body training method that emphasises posture, flexibility, core stability and neuromuscular control. The sequence exercises emphasise the importance of controlled movement, breathing and activation of deep stabilising muscles to restore muscular balance and good spinal alignment. Pilates is beneficial to individuals with forward head posture to stretch short muscles and improve weak deep cervical flexors and scapular stabilisers. This promotes cervical alignment, body awareness and movement efficiency. Pilates exercises have been demonstrated to improve function and reduce neck disability and impairment in those with postural problems [19,20]. Both interventions were demonstrated to produce beneficial effects on postural and neck conditions. There is limited evidence on the direct comparison of the craniovertebral angle, neck pain and disability in young adults with forward head position. The objective of this research was to find out the impact of Pilates Mat and Kendall exercises on reducing forward head posture.

METHODS

Study Design, Setting, Participants and Blinding

This pilot randomised controlled trial was conducted according to the standards of the CONSORT 2010, as mentioned in Figure 1. The trial was not prospectively registered in a clinical trial registry and was conducted in accordance with the ethical norms of the Declaration of Helsinki, with approval obtained from the Institutional Ethics Committee (033/08/2025/ISRB/PHDSR/SCPT). Each participant signed a consent form after being thoroughly educated about the study's objectives, methodology and possible risks. The trial was conducted at the Saveetha medical college and Hospital between August and September 2025. To ensure objectivity, outcome measures, including CVA, pain and NDI, were evaluated by an independent physiotherapist who was blinded to the group allocation. The physiotherapists who delivered the Pilates mat exercises and Kendall exercises were not involved in the data collection and analysis. Participants were blinded to their group assignment to prevent expectancy bias.

Eligibility Criteria

The participants were both genders, aged 18-25 years, with a clinical assessment of Forward Head Posture. Eligible participants were those with a Craniovertebral Angle (CVA) <54° measured using standardized lateral-view photographic assessment and sedentary lifestyle was assessed using Sedentary behaviour questionnaire. Participants with visual impairment or musculoskeletal problems (e.g., history of surgery on the shoulder or cervical spine, cervical or thoracic fractures, structural or functional scoliosis, excessive thoracic kyphosis, or under treatment for neck pain, postural syndrome, or cervical dysfunction) were excluded from the study.

Recruitment and Randomisation

As this was an exploratory pilot trial, no formal a priori sample size estimate was determined. The sample size was 17 participants for each group, which is consistent with the commonly recommended sample sizes for pilot and feasibility studies. For all participants, baseline anthropometric and demographic information (age, gender, height, weight and BMI) was obtained. The results revealed no significant variations between groups ($p>0.05$), as shown in Table 1. Eligible participants who met the pre-specified inclusion and exclusion criteria were randomly assigned to either the Pilates Mat exercise group or the Kendall exercise group using a computer-generated random allocation sequence. Randomisation sequence was generated by an investigator not involved in participants recruitment or outcomes assessment. Allocation was concealed from the investigators in sequentially numbered, opaque, sealed envelopes. Following the baseline assessment, the next envelope was opened to identify which group the participant was assigned to. Blinding of participants was not possible due to the nature of the exercise interventions however outcome assessment was completed by an assessor blinded to group allocation. Statistical analysis was performed by an investigator concealed owing to group allocation.

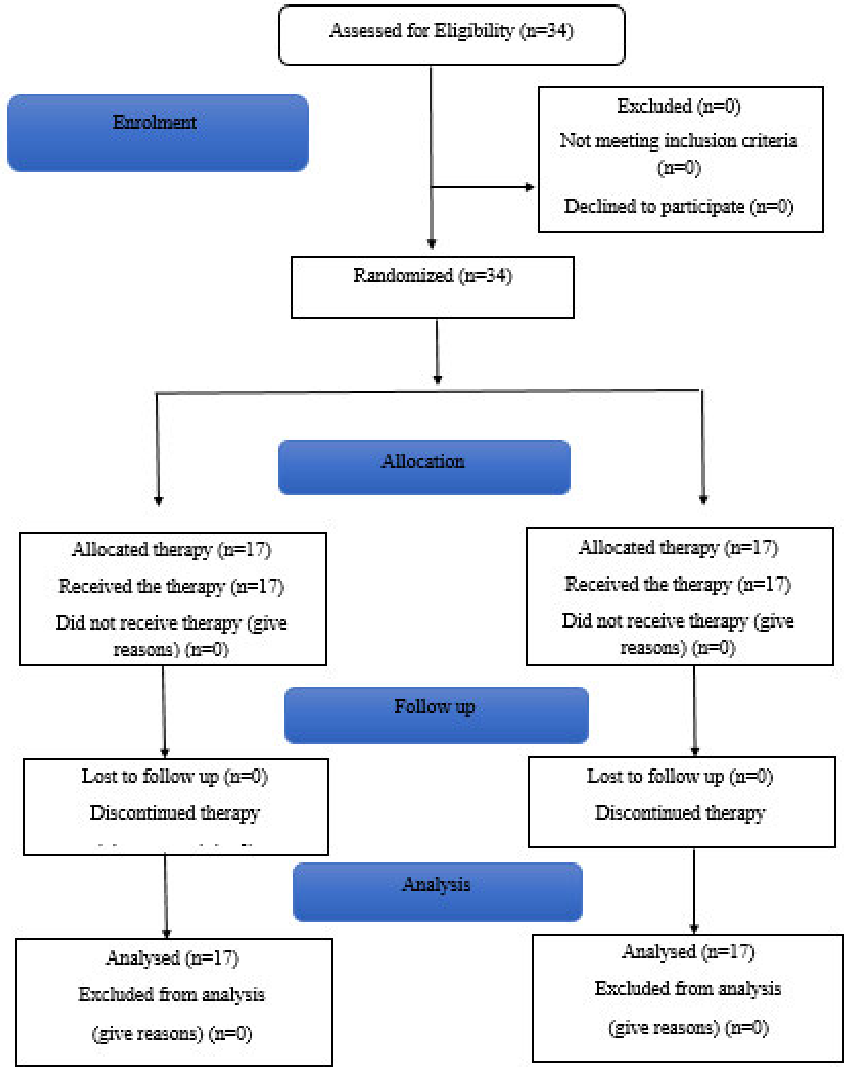

Figure 1: CONSORT Flow Diagram of Distribution of Participation and Recruitment

Table 1: Baseline Characteristics of Pilates Mat and Kendall Exercise

Variable	Pilates Mat Exercise Mean ± SD	Kendall Exercise Mean ± SD	p value
Age (years)	20.76±2.195	20.71±2.054	0.936
Height (cm)	162.06±4.322	162.24±4.236	0.905
Weight (kg)	54.35±4.541	54.29±4.370	0.970
BMI (kg/m²)	20.671±0.5654	20.653±0.5222	0.925
Gender (n%)	Frequency (Percentage)		
Male	7 (41.2%)	6 (35.3%)	0.724

The groups were coded as Group A and Group B until completion of the analysis. All participants underwent a baseline pre-test assessment and standard documentation. Both treatments were performed for 8 weeks, 4 days a week, 60 min per session. Post-test outcome measures were recorded after completion of the intervention period using the CVA, NPRS and NDI to evaluate treatment efficacy at the 4th week and the 8th week.

Intervention

Pilates Mat Exercises

All intervention sessions were supervised by a professional physiotherapist experienced in Pilates-based rehabilitation. The Pilates sessions comprised a warm-up, Pilates Mat exercises and cool-down activities. Each session lasted 60 min with 10 min of warm-up and 10 min of cool-down. All the participants were informed and demonstrated the five key concepts of Pilates prior to the intervention. These principles included: breathing techniques, concentration, core engagement (rib cage and shoulder stabilisation) and precise head and neck positioning. The Pilates mat exercise regimen included 10 standardised exercises that were executed by all participants in each session of the 8-week intervention. For each exercise, 1 set of 6-12 repetitions was performed. The protocol of exercises was identical for all individuals as shown in Table 2 [21].

Table 2: Pilates Mat Exercises

Exercise	Description
Level one Hip twist	The right knee moves away from the midline and back, with the spine in a neutral position. This makes it more difficult for the lumbar spine to control rotation.
Level one double leg stretch	The arms are extended overhead to the maximum while maintaining adequate control over the position of the rib cage and pelvis.
Level two double leg stretch (level 2)	This is done as in Level One, with the addition of moving the right heel away from the body along the mat while maintaining core stability.
One leg stretches, Level one	Slide the right heel along the mat slowly and extend the right leg, not allowing the pelvis to tilt forward.
Level one clam	The superior knee is elevated slowly towards the ceiling while the pelvis remains stable. This movement specifically targets the back fibres of the gluteus medius.
Level one shoulder bridge	The lumbar and thoracic spine are slightly flexed, creating a posterior pelvic tilt, while the pelvis is raised from the mat.
Level one scissors	Hold the pelvis in the neutral position and lift the right knee to the level of the hips so that the angles at the knee and the hip joints are approximately 90°
Level one arm openings	The upper arm is lifted away from the body to allow thoracic and lumbar rotation and encourage upper chest expansion.
Level one Breast stroke prep	The shoulder blades are lightly pushed down and away from the ears, to preserve appropriate scapular placement, while lifting the arms roughly 45 cm (18 inches) above the mat.
Level two Breaststroke prep	The upper trunk is elevated off the mat such that the breastbone is about 3 cm above the mat, maintaining a neutral lumbar spine and pelvis. This exercise increases coordinated use of the upper and lower trapezius, the serratus anterior, and deep neck flexor and extensor muscles.

Kendall Exercise [18]

Each Kendall exercise session was conducted for 60 minutes, four days per week for eight weeks, consisting of a 10-minute warm-up, 40 minutes of Kendall exercises and a 10-minute cool-down.

Cervical Extensors Stretching

Participants were instructed to sit or stand in an upright position, gently pull the chin back in order to produce a double chin, hold for 10 seconds, relax and repeat the exercise for 10 repetitions per set, 3 sets per session.

Shoulder Retraction Strengthening

Participants completed 10 repetitions per set of scapular retraction with an elastic resistance band with the shoulders abducted to 90° and elbows flexed, for 3 sets per session.

Pectoralis Muscle Stretching

Participants performed a doorway pectoralis stretch with arms at shoulder height and elbows bent at 90° and leaned forward until a stretch was felt in the chest. The participants performed 10 repetitions in each set for 3 sets per session.

Deep Cervical Flexors Strengthening

Participants performed deep cervical flexor exercises in the supine position with knees bent by pulling the chin in and flexing the head towards the chest, holding for 10 seconds. They completed 10 repetitions in each set for 3 sets per session.

Cointervention

During the study period, participants were instructed not to participate in any other neck exercises, physiotherapy, Pilates, structured exercise or ergonomic treatments. They were also advised not to take any pain medication or any other treatment for their neck discomfort.

Outcome Measures

Craniovertebral Angle (CVA): The Craniovertebral Angle (CVA) is a typical measure of Forward Head Posture (FHP) with <54° indicating FHP based on previous clinical criteria. The assessment is based on standardised digital photogrammetry. It is the angle between a horizontal line through the spinous process of the C7 vertebra and a line from the tragus of the ear to C7. A digital camera was positioned at around 1.5 m from the participant, at the level of C7 and perpendicular to the participant sagittal plane. Three lateral pictures were taken and the measurements averaged to produce the final CVA value. The images were processed using Kinovea software to obtain the CVA. Previous study has demonstrated of CVA measurement using digital photogrammetry, with reported inter-rater and test-retest ICCs of 0.92 and 0.89, respectively [22].

Numerical Pain Rating Scale (NPRS)

The NPRS is an 11-point self-report scale that is used to measure pain severity, where 0 represents no pain and 10 represents the most severe Pain. Participants were asked to pick the number that best described their current levels of neck pain at the time of assessment. It is a basic and easy-to-administer tool that is commonly used in both clinical and research settings. The measure has shown good test-retest reliability (ICC = 0.95-0.96) and strong concurrent validity with the Visual Analog measure (VAS, r = 0.86-0.95). The results indicate that the NPRS is a valid and accurate assessment of pain intensity for persons with musculoskeletal disorders [23].

Neck Disability Index (NDI)

NDI is a self-reporting questionnaire to evaluate impairment due to neck discomfort and its effect on activities of daily living. It consists of 10 items: pain intensity, personal care, lifting or bending, reading, headaches, concentration, work, driving, sleeping and recreation. Each item is scored from 0 to 5, so the overall score spans from 0 to 50, with higher scores representing greater neck-related disability. The original English version of the NDI was used in the present study [24].

Statistical Analysis

Data was analysed using SPSS Statistics version 27.0. The normality of the data was evaluated using Shapiro-Wilk test, histogram and Q-Q plots before inferential analysis to analyze the distribution of variables. The data were normally distributed and so the assumptions of parametric testing were confirmed. Homogeneity variances were analysed by Levens test and sphericity was analysed by Mauchly's test. Parametric tests were used since the data had a normal distribution. A two-way repeated measures ANOVA was used to evaluate the effects of time (Baseline, 4th week and 8th week), group (Pilates Mat and Kendall exercise group) and the time × group interaction on the outcome variables (CVA, NPRS and NDI). Mauchly's test of sphericity was used to assess the sphericity assumption. When sphericity was violated, Greenhouse–Geisser-corrected degrees of freedom and p-values were reported. Bonferroni-adjusted pairwise comparisons were performed for significant time effects. Effect sizes were reported using partial eta squared (ηp^2). Mean differences and 95% confidence intervals were reported for the principal between-group comparisons where available.

RESULTS

At baseline (T0), there were no changes between the two groups for CVA (MD = - 0.06, p = 0.904), NPRS (MD = - 0.12, p = 0.749) and NDI (MD = - 0.23, p = 0.794). Pilates Mat progressed substantially better Kendal exercise in CVA (47.71±1.160 Vs 45.06±1.298; MD = 2.65, p<0.001), NPRS (6.35±0.862 Vs 7.47±1.125; MD = −1.12, p = 0.003) and NDI (25.76±2.223 Vs 32.29±2.229; MD = − 6.53, p<0.001) in the 4th week (T4). At T8, Pilates Mat group had considerably better outcomes with greater CVA (53.29±1.359 Vs 48.24±1.200; MD = 5.04, p<0.001), lower NPRS (3.59±0.939 Vs 6.12±1.111; MD = −2.53, p<0.001) and lower NDI (11.88±1.317 Vs 25.47±1.328; MD = −13.59, p<0.001). During the 8-week intervention period, Pilates Mat showed significantly enhanced cervical posture, reduced pain intensity and neck disability changes than Kendall exercise group (Table 3). An increase in CVA values indicates an improvement in forward head position and a decrease in NPRS and NDI scores indicates a decrease in pain intensity and neck-related disability changes than Kendall exercise group. Both groups improved over time, but the degree of improvement was consistently greater in Pilates Mat at each follow-up evaluation. The data indicated that Pilates Mat intervention contributed to better clinical results than Kendall exercise treatment.

Levene's test indicated that variances were homogenous for NPRS, NDI and CVA at baseline, 4 weeks and 8 weeks (all p>0.05). Mauchly's test confirmed sphericity for NPRS (W = 0.828, χ^2 = 5.869, p = 0.053) and repeated-measures ANOVA revealed significant effects of time (F = 651.758, p<0.001, partial η^2 = 0.953), time × group interaction (F = 68.349, p<0.001, partial η^2 = 0.681) and group (F = 14.210, p = 0.001, partial η^2 = 0.308). Sphericity was violated for NDI (W = 0.688, χ2 = 11.601, p = 0.003). Greenhouse–Geisser correction was used. Significant effects were found for time (F = 1261.047, p<0.001, partial η^2 = 0.975), time × group interaction (F = 199.750, p<0.001, partial η^2 = 0.862) and group (F = 121.293, p<0.001, partial η^2 = 0.791), with more improvement in Pilates Mat group. For CVA, the sphericity assumption was violated (W = 0.804, χ^2 = 6.750, p = 0.034). The Greenhouse–Geisser correction indicated significant effects of time (F = 1189.452, p<0.001, partial η^2 = 0.974), time × group interaction (F = 135.310, p<0.001, partial η^2 = 0.809) and group (F = 38.355, p<0.001, partial η^2 = 0.545), with greater improvement observed in Pilates Group. All three outcomes showed significant treatment-related improvements with Pilates Mat group demonstrating better outcomes overall as mentioned in Table 4.

Table 3: Comparison of CVA, NPRS and NDI between Group A and Group B across Baseline, 4th Week and 8th Week Assessments

Outcome Measure	Time Point	Pilates Mat (Mean ± SD)	Kendall Exercise (Mean ± SD)	Mean Difference 95 % CI	p value
CVA	T0	43.18±1.425	43.24±1.393	– 0.059 (-1.043 to 0.936)	0.904
	T4	47.71±1.160	45.06±1.298	2.647 (1.787 to 3.507)	<0.001
	T8	53.29±1.359	48.24±1.200	5.059 (4.163 to 5.954)	<0.001
NPRS	T0	8.53±1.007	8.65±1.115	– 0.12 (-0.860 to 0.625)	0.749
	T4	6.35±0.862	7.47±1.125	–1.12 (-1.818 to -0.418)	0.003
	T8	3.59±0.939	6.12±1. 111	- 2.53 (-3.248 to -1.810)	<0.001
NDI	T0	35.18±2.698	35.41±2.501	– 0.235 (-2.053 to 1.582)	0.794
	T4	25.76±2. 223	32.29±2.229	– 6.53 (-8.085 to -4.974)	<0.001
	T8	11.88±1.317	25.47±1.328	–13.59 (-14.512 to -12.664)	<0.001

Note: CVA: Craniovertebral Angle; NPRS: Numerical pain rating scale; NDI: Neck disability index. The mean difference was calculated as Pilates Mat group mean-Kendall exercise group mean

Table 4: Two-Way Repeated Measure ANOVA Analysis for CVA, NPRS and NDI across Baseline, 4th Week and 8th Week Assessments

Outcome Measure	Main Effect of Time F (p-value)	Partial η^2	Time × Group Interaction F (p-value)	Partial η^2	Main Effect of Group F (p-value)	Partial η^2
CVA	1189.452 (<0.001)	0.974	135.310 (<0.001)	0.809	38.355 (<0.001)	0.545
NPRS	651.758 (<0.001)	0.953	68.349 (<0.001)	0.681	14.210 (<0.001)	0.308
NDI	1261.047 (<0.001)	0.975	199.750 (<0.001)	0.862	121.293 (<0.001)	0.791

Note: CVA = Craniovertebral Angle, NPRS = Numerical Pain Rating Scale, NDI = Neck Disability Index, F = F-statistic, p = p-value, ηp^2 = partial eta squared. The main effect of time represents changes in the outcome measures across baseline, 4th week and 8th week; the time × group interaction represents differences in the pattern of change over time between the Pilates Mat and Kendall exercise groups; and the main effect of group represents the overall difference between the two groups across all assessment time points

Table 5: Bonferroni Post hoc Pairwise Comparisons for CVA, NPRS and NDI

Outcome Measure	Group	Comparison	Mean Difference	p-value
CVA	Pilates Mat	T0 vs T4	-4.529	<0.001
		T0 vs T8	-10.118	<0.001
		T4 vs T8	-5.588	<0.001
	Kendell Exercise	T0 vs T4	-1.824	<0.001
		T0 vs T8	-5.000	<0.001
		T4 vs T8	-3.176	<0.001
NPRS	Pilates Mat	T0 vs T4	2.176	<0.001
		T0 vs T8	4.941	<0.001
		T4 vs T8	2.765	<0.001
	Kendell Exercise	T0 vs T4	1.176	<0.001
		T0 vs T8	2.529	<0.001
		T4 vs T8	1.353	<0.001
NDI	Pilates Mat	T0 vs T4	9.412	<0.001
		T0 vs T8	23.294	<0.001
		T4 vs T8	13.882	<0.001
	Kendell Exercise	T0 vs T4	3.118	<0.001
		T0 vs T8	9.941	<0.001
		T4 vs T8	6.824	<0.001

Note: CVA: Craniovertebral Angle, NPRS: Numerical Pain Rating Scale, NDI: Neck Disability Index

Bonferroni-adjusted pairwise comparisons revealed significant within-group changes over T0, T4 and T8 for all outcomes (all $p<0.001$). For CVA, significant changes were observed in the Pilates Mat group at T0–T4 (MD = −4.529), T0–T8 (MD = −10.118) and T4–T8 (MD = −5.588) and in the Kendall Exercise group at T0–T4 (MD = −1.824), T0–T8 (MD = −5.000) and T4–T8 (MD = −3.176). For NPRS, the Pilates Mat group had changes of T0–T4 (MD = 2.176), T0–T8 (MD = 4.941) and T4–T8 (MD = 2.765) and the Kendall Exercise group had changes of MD = 1.176, MD = 2.529 and MD = 1.353, respectively. Changes at T0–T4 (MD = 9.412), T0–T8 (MD = 23.294) and T4–T8 (MD = 13.882) were noted for the Pilates Mat group, compared with MD = 3.118, MD = 9.941 and MD = 6.824, respectively, for the Kendall Exercise group. In general, all pairwise comparisons were significant and greater differences were observed in the Pilates Mat group as shown in Table 5.

DISCUSSION

The outcomes of this study reveal that Pilates Mat exercises and Kendall exercises are useful for improving forward Head Posture in Young Adults with Pilates Mat exercises demonstrating greater improvements in postural outcomes. The findings are consistent with previous research, supporting the effectiveness of exercise-based treatments in correcting postural problems and improving neck alignment. As this was a pilot randomised controlled study, the results should be evaluated in terms of statistical significance and clinical relevance. For the Pilates Mat group, the changes from baseline to T8 in CVA (10.11°), NPRS (4.94 points) and NDI (23.29 points) were statistically significant and above the MCID of 1.40°, 1.5 points and 5.5 points, respectively. The Kendall Exercise group showed clinically relevant improvements in CVA (5.00°), NPRS (2.53 points) and NDI (9.94 points) with all changes exceeding the respective MCID levels. Thus both interventions resulted in statistically significant and clinically meaningful improvements with a greater magnitude of improvements observed in the Pilates Mat group. The current study results are in line with Elhafez *et al.* [21], who reported that Pilates mat exercises have a significant positive effect on the improvement of the craniovertebral angle, the reduction of neck discomfort and neck dysfunction in individuals with forward head posture. These improvements have been suggested to be associated with the increased activation of deep cervical flexors, improved postural alignment and enhanced core stability. Comparable findings were reported by Yasasin *et al.* [25], who reported that Pilates exercise was more beneficial than the cervical stabilisation exercise in improving the craniovertebral angle, postural alignment and quality of life in patients with forward head posture. These improvements may be related to enhanced core stability, the activation of the deep cervical flexor muscles and postural control. Consistent with these observations, an improvement in the craniovertebral angle was noted, especially in the Pilates mat exercise group, which is contrary to the findings of Sikka *et al.* [26], who found no significant change in the craniovertebral angle in adolescents with forward head posture after four weeks of deep cervical flexor training. The greater improvement may be partly explained by the extensive nature of the Pilates movements, which may promote deep cervical flexors engagement, scapular control, core stability and postural awareness. Likewise, Abu-Taleb *et al.* [27] investigated the effectiveness of Global Postural Re-education combined with Kendall exercises on patients with forward head posture. They reported significant reductions in the craniovertebral angle, cervical ROM and Neck Disability Index in both groups. However, no significant changes across the groups were observed, which indicates that the simple Kendall exercises were equally helpful in improving postural alignment. The results are consistent with the present study, in which both intervention groups improved significantly, although overall improvement was greater in the Pilates mat exercise group. In line with the present findings, a study by Heydari *et al.* [28]

observed considerable improvement in the Craniovertebral Angle (CVA) after doing specific corrective exercises in students with a forward head position. The researchers suggested that this improvement may be related to strengthening the deep cervical flexors and scapular stabilisers and stretching the shortened muscles. These results support the potential benefits of corrective exercise regimens for improving forward head posture. Mun and Roh [29] investigated the effects of Pilates exercises for 60 minutes and 30 minutes. They found no variations between the two groups in terms of the improvements in craniovertebral angle, head posture, thoracic alignment, muscle strength and muscle endurance. The results show that a 30-minute Pilates session is sufficient to obtain significant improvements in posture. This reinforces the evidence that Pilates is an effective intervention for improving forward head position, regardless of the duration of physical activity. These findings of the present evaluation, which has identified specific exercise programs beneficial in improving postural alignment and functional outcomes, support these investigations. In summary, the results of the present investigation corroborate earlier findings that exercise-based therapies are beneficial in reducing forward head position. Both Pilates training and Kendall exercises demonstrated significant improvements, with the Pilates exercise group reporting greater benefits. These findings suggest that Pilates mat training may be beneficial in improving postural alignment and functional outcomes among young adults with forward head posture.

Limitations and Recommendations

The study was conducted on a relatively small sample size, which may restrict the generalizability of the findings. The research mainly depended on subjective clinical outcome measures. Furthermore, potential mechanisms such as deep cervical flexor activation, core stability and postural awareness were not directly assessed. Only short-term results were analysed with no follow-up measurement. In addition, each participant's postural habits, screen time and physical activity were not assessed on a daily basis during the investigation. Blinding of participants was not feasible which may have contributed to performance and expectancy bias. The lack of a no-treatment or control group also limits the ability to attribute the observed benefits to the treatments solely. Future research should investigate the long-term effects of these interventions using larger, multicentre samples, longer follow-up periods and appropriate control groups. The use of objective assessment techniques such as Electromyography (EMG) and three-dimensional posture analysis is recommended to provide further information on treatment outcomes. Future studies should assess the impact of screen time, physical exercise and daily postural practices on forward head posture.

CONCLUSION

The present study indicated that both Pilates Mat exercises and Kendall exercises were beneficial in correcting forward head posture, neck pain and neck-related impairment in young adults. The improvements in CVA, NPRS and NDI were more noticeable in Pilates Mat exercises than in Kendall exercises. The extent of the between-group changes observed suggest that there may have been clinically important improvements in cervical alignment, pain and neck associated impairment. The results show that Pilates Mat exercises may be a more effective exercise-based method to improve postural and clinical outcomes in young adults with forward head posture.

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Credit Author Contributions

Akshaya Rajendra Prasad: Investigation, data curation, visualization and preparation of the original draft of the manuscript. Iswarya Suresh: Conceptualization, methodology, supervision, project administration, validation, correspondence and writing, reviewing and editing the manuscript. Shenbaga Sundaram Subramanian, Venkatesalu Padmavathi and R. Balasubramanian: Methodology, validation and critical review and editing of the manuscript. Anitha Arul: Conceptualization, methodology, supervision, validation and critical. Vidhya Thirunavukkarasu and Porkodi Arjunan: Review and editing of the manuscript. Syed Abudaheer and Hazliza Razali: Formal analysis. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Informed Consent Statement

Written informed consent was obtained from all participants prior to participation in the study. All participants were informed of the study purpose, procedures, associated benefits and their right to withdraw at any time.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Statement

The Institutional Ethics Committee approved the study, which adhered to the Declaration of Helsinki (033/08/2025/ISRB/PHDSR/SCPT).

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