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Effects of Pilates Exercise on Posture and Cervical Function in Individuals with Forward Head Posture: A Randomized Controlled Trial

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ABSTRACT

This randomized controlled trial investigated the effects of Pilates exercises on posture, neck pain, cervical range of motion (ROM), quality of life, and body composition in individuals with forward head posture (FHP). Thirty-six participants (mean age: 30.05 ± 8.21 years) with FHP (craniovertebral angle <54°) were randomly assigned to a Pilates group (n=18) or a cervical stabilization exercise (CSE) group (n=18). The Pilates group completed progressive mat and equipment-based exercises twice weekly, while the CSE group performed daily cervical stabilization routines. Outcomes included CVA, neck pain (VAS), posture (NYPRS), cervical ROM, SF-36 scores, and body composition. Assessments were conducted at baseline and post-intervention. Both groups improved significantly in CVA and neck pain (p<0.001). The Pilates group achieved greater gains in CVA (5.41° vs. 3.3°, p=0.016, d=0.55), posture (NYPRS: 4.27 vs. 1.61, p=0.007, d=0.81), and right lateral flexion ROM (6.66° vs. 2.27°, p=0.001, d=0.70). Pilates also reduced waist circumference (p=0.002, d=0.60). Pain reduction did not differ significantly between groups (p=0.298). In conclusion, Pilates exercises were more effective than cervical stabilization in improving posture, cervical mobility, and body composition in individuals with forward head posture.

This randomized controlled trial was retrospectively registered at ClinicalTrials.gov under the number NCT06883721 on March 5, 2025.

Keywords: Forward head posture, Pilates exercises, Neck pain, Craniovertebral angle, Cervical stabilization, Randomized controlled trial.

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INTRODUCTION

Proper posture is essential for maintaining musculoskeletal balance and minimizing excessive strain on the body. A well-aligned posture distributes mechanical loads efficiently, preventing structural imbalances and musculoskeletal disorders [1]. However, postural misalignments have become increasingly prevalent due to sedentary lifestyles, prolonged screen use, and occupational demands [2]. Among these dysfunctions, forward head posture (FHP) is one of the most common postural deviations observed globally, particularly in the sagittal plane [3]. Epidemiological studies report a high prevalence of FHP across diverse populations, with rates of 63.96% among university students [4] and 73% in younger individuals [5]. While prevalence rates vary by age, adults with sedentary habits or prolonged screen exposure remain particularly susceptible [6].

FHP is characterized by anterior displacement of the head relative to the cervical spine, leading to hyperextension in the upper cervical region (C1–C3) and increased flexion in the lower cervical region (C4–C7). This malalignment disrupts the natural curvature of the spine, contributing to neck pain, musculoskeletal discomfort, functional impairments, and abnormal muscle activation patterns in the neck, suboccipital, and shoulder girdle muscles [7]. The forward displacement of the head's center of mass increases mechanical load on the cervical spine, predisposing individuals to neuromusculoskeletal and vascular complications [8]. Furthermore, FHP is closely associated with Upper Crossed Syndrome (UCS), a postural disorder marked by thoracic hyperkyphosis, rounded shoulders, and cervical imbalances [9].

Craniovertebral angle (CVA), measured as the angle between the tragus of the ear, the C7 spinous process, and a horizontal line, is a widely used metric to quantify FHP severity [10]. Reduced CVA values correlate strongly with cervical pain, restricted range of motion (ROM), and postural instability [11]. Therapeutic exercises, including cervical stabilization and postural correction programs, are commonly employed to address these issues. CSE, particularly target deep neck flexors and scapular stabilizers, aiming to correct muscle imbalances and alleviate pain [12,13]. However, recent literature emphasizes the need for holistic interventions that integrate core stability, flexibility, and postural awareness—principles central to Pilates [14].

Pilates, a mind-body exercise approach emphasizing core stabilization, breath control, and postural alignment, aims to improve postural symmetry, muscle endurance, and body composition [15]. While studies highlight its benefits for spinal alignment and pain reduction, evidence on its efficacy for FHP remains limited, particularly regarding its comprehensive effects on ROM, quality of life, and body composition. Existing RCTs predominantly assess isolated parameters, highlighting a gap in comprehensive investigations [16].

This study hypothesizes that an 8-week Pilates intervention will significantly reduce neck pain, improve cervical ROM and postural alignment, enhance quality of life, and positively influence body composition compared to traditional CSE. By addressing these multifaceted outcomes, this study seeks to provide a robust evidence base for optimizing rehabilitation protocols for FHP.

METHODS

Study Design, Setting, and Participants

This randomized controlled trial (RCT) followed the CONSORT 2010 guidelines and utilized a pretest-posttest design. Ethical approval for the study was obtained from an independent ethics committee and conducted in accordance with the ethical principles of the Declaration of Helsinki. All participants provided written informed consent after receiving detailed explanations of the study’s purpose, procedures, and potential risks. The trial was conducted at Physiolab Physiotherapy Center in Antalya, Turkey, between January and May 2023.

Blinding Procedures

To ensure objectivity, outcome measures (CVA, pain, posture, ROM, quality of life, and body composition) were assessed by an independent physiotherapist who was blinded to the group allocation. The physiotherapists responsible for delivering the Pilates and cervical stabilization interventions were not involved in data collection or analysis. Participants were not informed about their group assignment to minimize expectation bias.

Participants: This study included adult participants who met specific inclusion criteria and had no exclusion criteria, as detailed below.

Inclusion Criteria:

- Adults aged 18–50 years.
- Craniovertebral angle (CVA) <54°
- Sedentary lifestyle

Exclusion Criteria:

- History of spinal surgery (cervical/thoracic/lumbar) or

neurological disorders.
- Acute or severe cervical trauma (e.g., fractures, whiplash injuries).
- Spinal deformities (e.g., scoliosis, kyphosis).
- Recent physiotherapy/manual therapy (within the past 6 months).
- Regular use of analgesics, muscle relaxants, or steroids.
- Active participation in regular exercise

Recruitment and Randomization: Participant recruitment and randomization were conducted as follows. Initially, 40 participants (29 females [80.5%], 7 males [19.5%]) were enrolled. During the study, four participants (two from each group) withdrew due to personal reasons unrelated to the intervention, resulting in a final sample of 36 participants (18 per group). Participants were randomly allocated into two groups: Pilates Intervention Group Cervical Stabilization Control Group Randomization was performed by an independent third party using an online random number generator (https://www.randomizer.org/) to ensure allocation concealment. Baseline demographic and anthropometric data (age, gender, BMI, and waist-to-hip ratio) were collected for all participants, with no significant differences observed between groups ($p > 0.05$).

Intervention Timeline: The study timeline encompassed the following key phases: Data Collection: Conducted at baseline (Week 0) and post-intervention (Week 8). Intervention Duration: 8 weeks.

Intervention

Pilates Intervention: The Pilates intervention was conducted twice a week for 60 minutes per session over an 8-week period at the physiotherapy center. All sessions were conducted under necessary institutional approvals and supervised by a licensed physiotherapist. Prior to the intervention, participants attended an introductory session detailing the fundamental principles of Pilates. These principles included: breathing techniques, concentration, core engagement (rib cage and shoulder stabilization), and precise head and neck positioning**.** Throughout all sessions, maintaining proper postural alignment based on these Pilates principles was consistently emphasized.

The Pilates program was progressively structured to increase in difficulty over time. Pilates balls and 1-kg dumbbells were introduced in Week 2, red resistance bands in Week 4, and green resistance bands in Week 6. Each session consisted of:

- 10-minute warm-up phase
- Sessions progressed from mat-based exercises to equipment-based exercises to enhance engagement and effectiveness
- 10-minute cool-down phase

Table 1. Pilates exercise program and progression during Weeks 0–8

	Weeks 0-4	Weeks 4-8
Mat	Spine Stretch	Half Curl
	Spine Twist	Half Push-Up
	Roll Up	Hip Rolls
	Crunch	Half Squeeze
	Oblique Crunch	
	Single Leg Stretch	
	Half Swan	
Reformer	Footwork Series	Short Box Oblique Roll Back
	Single Leg Raise	Long Box Swan Dive
	Up and Down	Mermaid
	Posture Series	Lower Back Stretch
	Seated Posture Series	Side Twist
	Short Box Round Back	
Cool-down	Superman	Superman
	Swimming	Cat Stretch
		Plank

During Weeks 0–4, exercises were performed for eight repetitions, increasing to ten repetitions in Weeks 4–8. The specific exercises included in the program are outlined in Table 1.

Control Group: Cervical Stabilization Program: Both the Pilates and control groups also received ergonomic guidelines for daily activities throughout the 8-week study period. The control group participated in a structured cervical stabilization program, designed to enhance postural alignment and neuromuscular activation. Exercises were performed twice daily in two sets of ten repetitions:

- Cervical Retraction (Chin Tuck): Retract the chin while maintaining a neutral head position, hold for 3 seconds, repeat 10 times.
- Cervical Extension: Support the lower cervical region with the hands while extending the spine, hold for 3 seconds, repeat 10 times.
- Shoulder Elevation: Elevate the shoulders, hold for 3 seconds, repeat 10 times.
- Scapular Retraction: Retract the scapulae while maintaining a neutral spine, hold for 3 seconds, repeat 10 times.

This comprehensive regimen was designed to improve cervical stability, alleviate pain, and enhance postural control in the control group.

Outcome Measures

For this study, the Cervical Vertebral Angle (CVA) and pain intensity (VAS) were designated as the primary outcome measures, while posture, range of motion (ROM), quality of life, and body composition were considered secondary outcome measures. Clinical outcome measures were assessed at baseline (week 0) and at the end of the 8-week intervention (week 8). All outcome measures were collected by an experienced physiotherapist who was blinded to the group allocation to ensure objectivity. Before each measurement, participants received detailed instructions and verbal guidance to ensure proper execution and reliable results. During the procedures, real-time feedback was provided to correct misalignments or errors.

Craniovertebral Angle (CVA)

The craniovertebral angle (CVA), a key metric and a widely used measure for assessing forward head posture (FHP), was evaluated using standardized digital photogrammetry [17]. Lateral photographs were captured using a Fujifilm XT-3 mirrorless camera equipped with a 35mm lens. This standardized digital photogrammetry method involved participants standing in a relaxed upright posture, focusing on a fixed point at eye level (a wall-mounted marker). The spinous process of the seventh cervical vertebra (C7) and the tragus of the ear were palpated and marked with reflective adhesive markers to ensure precise landmark identification. Participants were instructed to remain motionless during the imaging process.

Images were analyzed using ImageJ software (v1.53 version, LOCI, University of Wisconsin). The CVA was calculated as the angle between a line connecting the tragus and C7 markers and a horizontal reference line parallel to the floor (Figure 1) [11]. This protocol demonstrated excellent reliability, with intraclass correlation coefficients (ICCs) of 0.92 for inter-rater consistency [17] and 0.89 for test-retest reliability [18]. The validity and reliability of this method for both standing and seated postural evaluations have been previously established [18].

Figure 1. CVA measurement.

Pain Intensity (VAS)

Neck pain intensity was assessed using the Visual Analog Scale (VAS), a 10 cm line from 0 (no pain) to 10 (unbearable/most severe pain) *with participants instructed to rate their* neck-specific discomfort. VAS scores were categorized as mild (0-3.4 cm), moderate (3.5-7.4 cm), and severe (7.5-10 cm) pain [19]. Analysis of average pain intensity and changes in pain intensity evaluated the effectiveness of the applied intervention.

Posture (NYPRS)

Posture was assessed using the New York Posture Rating Scale (NYPRS), a secondary outcome measure. This method scores 13 body regions (head, neck, shoulders, back, waist, abdomen, pelvis, and feet) from posterior and lateral views, assigning 5 points for good posture, 3 points for moderately impaired posture, and 1 point for severely impaired posture. Total scores range from 13 (worst) to 65 (best) and are interpreted as: ≥45 (very good), 40-44 (good), 30-39 (fair), 20-29 (poor), and ≤19 (very poor) [20]. Participants were assessed in a relaxed standing position, and scores were recorded.

Range of Motion (ROM)

Cervical range of motion (ROM), a secondary outcome measure, encompassing flexion, extension, lateral flexion, and rotation, was measured using a standard universal goniometer according to established protocols. Participants sat upright with back support, holding a tongue depressor between their teeth, with shoulder girdle stabilization. The goniometer fulcrum was placed at anatomical landmarks (e.g., external auditory meatus for flexion/extension, C7 spinous process for lateral flexion). Maximum ROM angles were recorded in degrees (mean of two trials). Measurements were taken by an experienced physiotherapist. Recent research has shown goniometry to have excellent test-retest and inter-rater reliability for assessing cervical ROM in individuals with chronic neck pain [21].

Quality of Life

For quality of life assessment, the Short Form-36 (SF-36) scale, a secondary outcome measure, was used. This 36-item scale evaluates participants' health status over the past 4 weeks. The SF-36 consists of eight subscales: physical functioning, role-physical, role-emotional, energy/vitality, mental health, social functioning, pain, and general health perceptions. Separate scores are calculated for each subscale. The subscales assess health on a scale of 0-100, where 0 represents poor health and 100 represents good health [22].

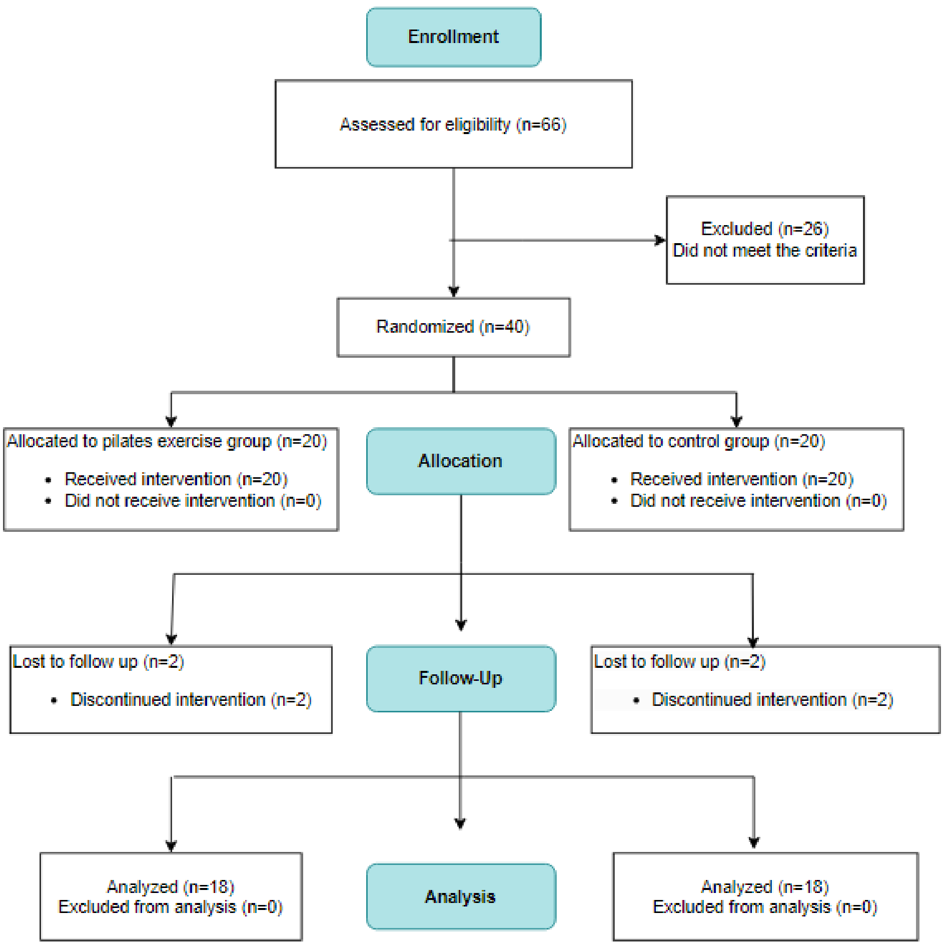

Figure 2. CONSORT study flow diagram

Body Composition

To evaluate body composition, a secondary outcome measure, anthropometric measurements were utilized. Height was measured using a standard stadiometer, and weight was measured using a calibrated scale. The Body Mass Index (BMI) was calculated using height (in cm) and weight (in kg) measurements with the formula: BMI = Weight (kg) / Height $(m)^2$. Chest circumference (cm) was measured at the nipple line; waist circumference (cm) at the narrowest point (approximately 2 cm above the navel); and hip circumference (cm) at the widest point, using a non-stretchable measuring tape with the participant in a standing position and breathing normally. The waist-to-hip ratio was calculated using waist and hip circumference measurements with the formula Waist-to-Hip Ratio = Waist Circumference (cm) / Hip Circumference (cm). Standard anatomical reference points were used for all circumference measurements.

Data Analysis

Analyses were performed using IBM SPSS Statistics (v29.0). Normality was assessed via the Kolmogorov-Smirnov test. Key variables (e.g., CVA, ROM, VAS, posture, SF-36 subscales, body composition) were summarized with descriptive statistics (mean ± SD or median [IQR]) and analyzed using paired samples t-tests/Wilcoxon tests (within-group) or independent t-tests/Mann-Whitney U tests (between-group), depending on data distribution. Relationships between variables were examined via correlation analyses (Pearson/Spearman). Effect sizes were calculated (Cohen's d for parametric tests: small=0.2, medium=0.5, large≥0.8). For between-group comparisons, Cohen's d was computed using post-intervention means and pooled standard deviations. All analyses were conducted at a 95% confidence level ($p < 0.05$).

RESULTS

Participant flow through the study is detailed in Figure 2.

Table 2. Comparison of Demographic and Baseline Body Composition Values Between Groups

Characteristic	Pilates Group (n=18)	Control Group (n=18)	p value
Age (years)	32.3 ± 8.21	27.8 ± 7.68	.107
Height (cm)	163.4 ± 6.93	166.8 ± 6.75	.147
Weight (kg)	64.27 ± 11.03	61.5 ± 11.39	.601
BMI (kg/m²)	24.03 ± 3.11	22.07 ± 3.02	.064
Chest Circumference (cm)	95.66 ± 5.07	91.22 ± 10.67	.120
Waist Circumference (cm)	80.22 ± 7.64	75.57 ± 11.44	.161
Hip Circumference (cm)	104.61 ± 7.91	98.77 ± 8.27	.118
Waist/Hip Ratio	0.765 ± 0.05	0.76 ± 0.06	.799
Gender			
Male (n)	3 (16.7%)	4 (22.2%)	
Female (n)	15 (83.3%)	14 (77.8%)	

Results are presented as mean ± SD or n (%). BMI: Body Mass Index

Initially, 66 individuals were assessed for eligibility based on the predefined inclusion and exclusion criteria. Of these, 26 individuals were excluded for various reasons. The remaining 40 eligible participants were then randomized into two equal groups (n=20 per group): the Pilates group and the control group. Throughout the study period, a total of four participants (two from each group) withdrew due to personal reasons unrelated to the intervention. Consequently, data from 36 participants (18 in each group) were available for the final analyses.

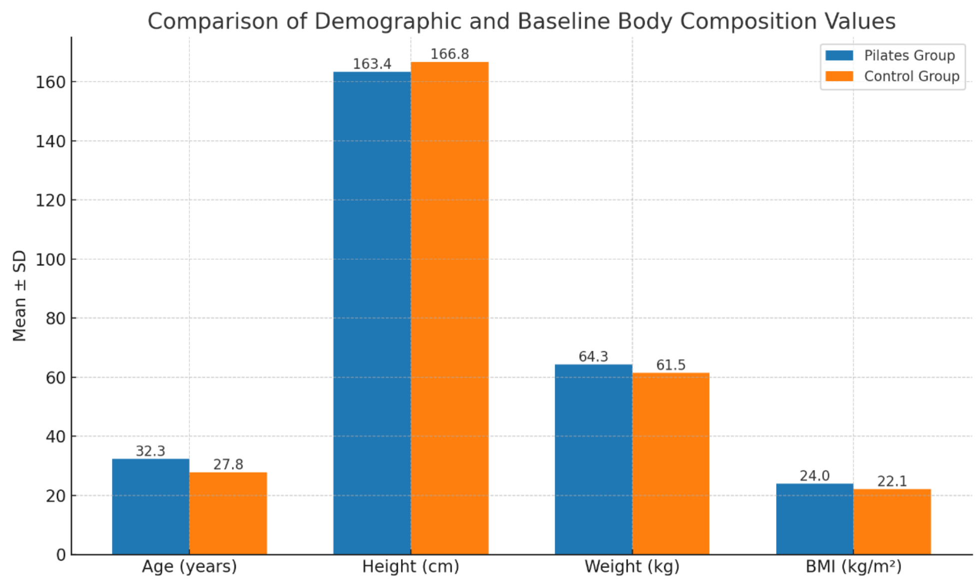

***Figure 3**. Comparison of demographic and baseline body composition values*

A total of 36 participants were included in this study, with 18 participants in the Pilates group and 18 participants in the control group. The demographic characteristics and baseline body composition values of the participants are presented in Table 2. The mean age of the pilates group was 32.3 ± 8.21 years, while the mean age of the control group was 27.8 ± 7.68 years. The Pilates group consisted of 15 females (83.3%) and 3 males (16.7%), while the control group included 14 females (77.8%) and 4 males (22.2%). There were no statistically significant differences between the groups at baseline for any of the demographic or body composition variables (all $p > 0.05$).

Figure 3 provides a visual comparison of baseline demographic and body composition values, including age, BMI, and circumference measurements, between the Pilates and control groups. The figure confirms that no statistically significant differences were observed between the groups.

Table 3 presents within- and between-group changes in CVA, VAS, and NYPRS scores post-intervention, including effect sizes (Cohen's d). Both groups demonstrated significant within-group improvements in CVA and VAS ($p < .001$ for both). Pilates also resulted in a significant improvement in NYPRS ($p < .001$), while the control group showed a less pronounced improvement ($p = .003$). Between-group comparisons showed a significant difference favoring Pilates for CVA ($p = .016$, $d = 0.55$) and NYPRS ($p = .007$, $d = 0.81$), indicating a moderate effect size for CVA and a large effect size for NYPRS. No significant between-group difference was observed for VAS ($p = .298$, $d = -0.59$). Figure 4 illustrates the pre- and post-intervention changes (Figure 4a) and the relationship between CVA and VAS scores (Figure 4b).

Pre- and post-intervention changes in cervical ROM are detailed in Table 4. Within-group analyses showed significant improvements in most ROM measures for both groups ($p<0.05$). Notably, changes in cervical flexion within the Pilates group ($p = 0.053$) and cervical extension within the control group ($p = 0.893$) did not reach statistical significance. Between-group comparisons revealed that the control group achieved significantly greater improvement in cervical extension ($p = 0.03$), whereas the pilates group demonstrated significantly greater improvement in right lateral flexion ($p = 0.001$).

Analysis of changes in Quality of Life (SF-36) subscales (Table 5) revealed statistically significant within-group improvements in several domains for both intervention groups ($p<0.05$). While both groups demonstrated improvements in Energy/Vitality and General Health, the pilates group also showed significant gains in Physical Role, Social Functioning, and Pain. The Control group similarly improved in Emotional Role and Mental Health. However, no statistically significant between-group differences were

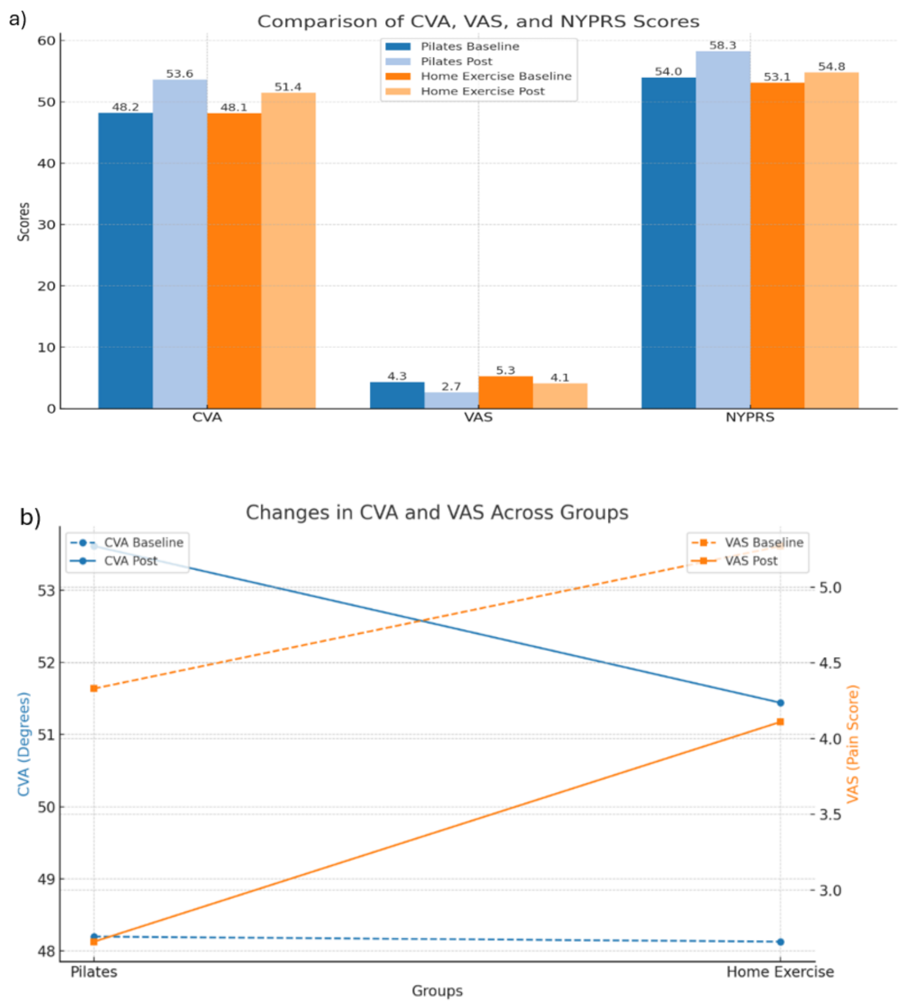

Figure 4. (a) Pre- and post-intervention changes in CVA, VAS, and NYPRS scores for the Pilates and Control groups. Error bars represent standard deviations. Significant improvements were observed within the Pilates group for all measures (CVA, p < .001; VAS, p < .001; NYPRS, p < .001), while the Control group demonstrated less pronounced improvements, particularly for NYPRS (p = .003). Between-group comparisons indicated significant differences favoring Pilates for CVA (p = .016) and NYPRS (p = .007), but not for VAS (p = .298). (b) Relationship between CVA and VAS scores post-intervention, analyzed separately for the Pilates and Control groups. A negative correlation was observed, indicating that greater improvements in CVA were associated with larger reductions in VAS scores (r = -0.45, p < .05). Error bars represent standard errors.

observed across any of the SF-36 subscales.

Analysis of body composition changes (Table 6) revealed significant within-group reductions in BMI, waist circumference, and waist-hip ratio within the Pilates group ($p < 0.05$). In contrast, no significant within-group changes were observed in the Control group. Between-group analysis demonstrated a statistically significant difference favoring the Pilates group for waist circumference (p=.002).

Table 3. CVA, VAS and NYPRS Following Intervention Within and Between Groups

Measure	Group	Baseline (Mean ± SD)	Post-Intervention (Mean ± SD)	Within-Group p Value	Between-Group Δ Value (Mean ± SD)	Between-Group p Value	Between-Group Cohen's d
CVA	Pilates	48.20 ± 4.11	53.61 ± 4.00	<.001	5.41 ± 2.73	.016	0.55
	Control	48.13 ± 3.74	51.44 ± 3.92	<.001	3.3 ± 2.24		
VAS	Pilates	4.33 ± 2.76	2.66 ± 2.80	<.001	-1.66 ± 1.64	.298	-0.59
	Control	5.27 ± 1.93	4.11 ± 2.02	<.001	-1.16 ± 1.15		
NYPRS	Pilates	54.00 ± 5.54	58.27 ± 4.08	<.001	4.27 ± 3.39	.007	0.81
	Control	53.11 ± 5.10	54.77 ± 4.52	.003	1.61 ± 1.97		

Δ: Change (Post-Intervention - Baseline). CVA: Craniovertebral Angle; NYPRS: New York Posture Rating Scale; VAS: Visual Analog Scale.

Table 4. Changes in Cervical ROM Following Intervention Within and Between Groups

Measure	Group	Baseline (Mean ± SD)	Post-Intervention (Mean ± SD)	Within-Group p Value	Between-Group Δ Value (Mean ± SD)	Between-Group p Value
Flexion	Control	70.61 ± 9.77	72.33 ± 9.65	.024	1.72 ± 2.94	.457
	Pilates	76.05 ± 9.87	78.94 ± 9.05	.053	2.88 ± 5.89	
Extension	Control	73.94 ± 7.96	78.66 ± 7.95	.021	4.72 ± 7.9	.03
	Pilates	81.44 ± 6.87	81.55 ± 8.03	.893	0.11 ± 3.44	
Right Rotation	Control	81.22 ± 7.19	83.11 ± 7.07	.001	1.88 ± 1.96	.329
	Pilates	81.61 ± 8.21	85.11 ± 5.09	.038	3.5 ± 6.6	
Left Rotation	Control	79.88 ± 11.26	82.83 ± 10.04	.012	2.94 ± 4.45	.316
	Pilates	81.94 ± 9.85	86.77 ± 5.88	.006	4.83 ± 6.49	
Right Lateral Flexion	Control	45.61 ± 8.69	47.88 ± 9.45	.006	2.27 ± 3.1	.001
	Pilates	42.88 ± 3.59	49.55 ± 4.60	<.001	6.66 ± 3.91	
Left Lateral Flexion	Control	45.83 ± 7.40	48.44 ± 8.00	.001	2.61 ± 2.61	.132
	Pilates	43.50 ± 4.90	47.94 ± 5.11	<.001	4.44 ± 4.3	

Δ: Change (Post-Intervention - Baseline). ROM: Range of Motion.

Table 5. Changes in Quality of Life (SF-36) Subscales Following Intervention Within and Between Groups

Subscales	Group	Baseline (Mean ± SD)	Post-Intervention (Mean ± SD)	Within-Group p Value	Between-Group Δ Value (Mean ± SD)	Between-Group p Value
Physical Function	Pilates	87.77 ± 12.97	93.61 ± 7.43	.123	5.83 ± 15.26	.798
	Control	83.33 ± 14.95	88.05 ± 12.96	.063	4.72 ± 10.06	
Physical Role	Pilates	75.36 ± 36.38	97.22 ± 8.08	.016	22.22 ± 35.23	.379
	Control	72.22 ± 30.78	84.72 ± 27.3	.095	12.5 ± 30.01	
Emotional Role	Pilates	57.40 ± 43.99	62.96 ± 41.04	.636	5.56 ± 48.84	.391
	Control	51.85 ± 39.97	68.5 ± 36.99	.008	16.65 ± 23.57	
Energy/Vitality	Pilates	47.5 ± 21.29	60.27 ± 19.28	.047	12.77 ± 25.27	.841
	Control	42.22 ± 18.72	53.61 ± 20.2	.004	11.39 ± 14.43	
Mental Health	Pilates	59.55 ± 14.23	66.22 ± 14.79	.119	6.67 ± 17.24	.615
	Control	48 ± 18.09	57.33 ± 19.06	.012	9.33 ± 14.12	
Social Functioning	Pilates	63.88 ± 19.12	76.25 ± 17.84	.02	12.37 ± 20.39	.599
	Control	59.3 ± 24.62	68.19 ± 23.02	.061	8.89 ± 18.77	
Pain	Pilates	61.25 ± 23.1	79.16 ± 14.9	.013	17.91 ± 27.28	.291
	Control	56.94 ± 25.77	66.25 ± 21.13	.07	9.31 ± 20.41	
General Health	Pilates	60.69 ± 13.6	72.5 ± 9.58	.004	11.81 ± 14.89	.271
	Control	59.44 ± 18.38	66.38 ± 15.6	.015	6.94 ± 10.86	

Δ: Change (Post-Intervention - Baseline). SF-36: Short Form-36

DISCUSSION

This study investigated and compared the effects of Pilates and cervical stabilisation exercises on craniovertebral angle (CVA), neck pain, body composition, quality of life, and range of motion (ROM) in individuals with forward head posture (FHP). The key finding was that Pilates yielded significantly greater improvements in posture and CVA compared to cervical stabilization exercises. This discussion elaborates on these results in comparison to the existing literature.

Consistent with our hypothesis, the Pilates group demonstrated significant improvements in CVA (from 48.2±4.11° to 53.61±4°), outperforming the CSE group ($p = .016$, $d = 0.55$, moderate effect size). These results align with Lee et al. (2016), who highlighted the positive effects of Pilates on FHP and CVA. Similarly, previous systematic reviews [6] have demonstrated that therapeutic exercises lead to significant improvements in CVA and moderate reductions in neck pain. This meta-analysis, based on seven randomized controlled trials, strongly supports the efficacy of exercise in improving CVA.

Clinically, a notable observation is that the mean CVA improvement in the Pilates group (5.41°) surpassed the minimal clinically important difference (MCID) of 1.40° [23]. Although this MCID was derived from selective corrective exercises performed on students with FHP, it provides a valuable benchmark for interpreting the clinical significance of these results. The substantial change in CVA observed in this study underscores the effectiveness of Pilates in addressing FHP and achieving clinically meaningful postural improvements.

Supporting these postural findings, a negative correlation was observed between FHP and neck pain, where increases in CVA were associated with reductions in pain intensity. Individuals with neck pain were reported to have lower CVA values and more restricted ROM [24]. Furthermore, Pilates was demonstrated to significantly improve posture in both children and adults, further corroborating these results [25]. Achieving these outcomes within an 8-week intervention highlights the potential of short-term exercise interventions in managing FHP effectively.

Postural improvements were a primary focus of this study. To evaluate changes in overall body posture, the New York Posture Rating Scale (NYPRS) was utilized. However, it should be noted that NYPRS, while effective for general assessments, is an older method that lacks the precision of modern technological approaches now available for postural evaluation. The Pilates group demonstrated significantly greater improvements in postural alignment compared to the cervical stabilization group ($p = .007$, $d = 0.81$, large effect size). Scapular stabilization exercises were reported to enhance postural alignment in individuals with FHP [26], which aligns with these results. Furthermore, similar postural benefits were observed following a 12-week Pilates program [27], consistent with our findings. The NYPRS findings underscore the importance of targeting global postural corrections to complement localized interventions such as CVA improvement.

Although both groups demonstrated significant within-group improvements in VAS scores, there was no significant between-group difference for neck pain reduction ($p = .298$). However, the effect size ($d = -0.59$, moderate) suggests that the control group experienced a slightly greater reduction in

Table 6. Changes in Body Composition Following Intervention Within and Between Groups

Measurement	Group	Baseline (Mean ± SD)	Post-Intervention (Mean ± SD)	Within-Group p Value	Between-Group Δ Value (Mean ± SD)	Between-Group p Value
Weight (kg)	Pilates	64.27 ± 11.03	63.72 ± 11.21	.086	-0.55 ± 1.29	.463
	Control	61.50 ± 11.39	61.44 ± 11.77	.901	-0.06 ± 1.86	
BMI (kg/m²)	Pilates	24.03 ± 3.11	23.76 ± 3.20	.026	-0.27 ± 0.46	.463
	Control	22.07 ± 3.02	22.30 ± 3.11	.665	0.23 ± 0.64	
Chest Circum. (cm)	Pilates	95.66 ± 5.07	96.16 ± 5.33	.302	0.50 ± 1.99	.829
	Control	91.22 ± 10.67	91.61 ± 10.39	.064	0.39 ± 0.83	
Waist Circum. (cm)	Pilates	80.22 ± 7.64	78.88 ± 7.42	<.001	-1.34 ± 1.12	.002
	Control	75.57 ± 11.44	75.66 ± 11.92	.780	0.09 ± 1.41	
Hip Circum. (cm)	Pilates	104.61 ± 7.91	104.77 ± 7.38	.700	0.16 ± 1.80	.346
	Control	98.77 ± 8.27	99.33 ± 8.81	.086	0.56 ± 1.29	
Waist/Hip Ratio	Pilates	0.765 ± 0.05	0.750 ± 0.05	<.001	-0.015 ± 0.01	.780
	Control	0.760 ± 0.06	0.740 ± 0.09	.285	-0.02 ± 0.06	

Δ: Change (Post-Intervention - Baseline). BMI: Body Mass Index. Circum.: Circumference.

pain compared to the Pilates group. While Pilates had a beneficial effect on pain relief, its impact was not significantly superior to cervical stabilization exercises. Previous studies have emphasized that pain perception is influenced by multiple factors beyond postural alignment, including muscle imbalances, cervical ROM, and neuromuscular adaptations [28]. The relationship between CVA and pain intensity has been well-documented, with lower CVA values being associated with increased pain levels [24, 29]. CVA values below 47° were reported to be significantly linked to higher pain severity, supporting the idea that postural correction may contribute to pain management [29]. However, the absence of a significant between-group difference in this study suggests that postural improvements alone may not fully explain pain reduction. While Pilates enhances postural awareness and musculoskeletal balance, cervical stabilization exercises specifically target deep stabilizing muscles and neuromuscular control, which may have provided additional pain modulation effects. Nonetheless, the significant improvements observed in both groups indicate that both exercise modalities play a valuable role in pain management for individuals with FHP.

Both groups in this study exhibited improvements in cervical ROM, with the Pilates group showing more significant increases in lateral flexion and rotation. While universal goniometers remain widely used for ROM measurements due to their accessibility and ease of use, it's worth noting that more advanced tools could offer greater precision and reliability, potentially enhancing the accuracy of these findings. Increased cervical flexion ROM in exercise groups has been reported [30], consistent with our findings. Moreover, scapular stabilization exercises were emphasized to contribute to ROM enhancements [26], which aligns with the results of this study. While this 8-week intervention yielded notable improvements, similar effects with a 12-week Pilates program on neck pain and ROM were observed [27]. These findings suggest that longer interventions could potentially yield even greater benefits, particularly for cervical ROM.

The SF-36 survey results indicated improvements in quality of life in both groups, with the Pilates group showing more pronounced improvements in social functioning and physical role parameters. Similar outcomes were reported in individuals with chronic neck pain, where Pilates effectively enhanced physical activity and reduced pain [31]. The biopsychosocial benefits of Pilates were further supported, aligning closely with these findings [32]. Additionally, significant improvements in physical function, pain, energy, and overall health were noted with Pilates, supporting these results [27]. However, the lack of long-term evaluations in this study highlights the need for future research to explore the sustained effects of these interventions on quality of life.

This study revealed significant improvements in body composition parameters, such as waist circumference and waist-to-hip ratio, in the Pilates group. It is essential to note that the inclusion of body composition measurements in this study was primarily intended to examine the broader, holistic effects of Pilates, rather than its direct relevance to FHP correction. This approach was designed to broaden the scope of the study and offer a more comprehensive understanding of Pilates' potential benefits. However, inconsistent results regarding Pilates' effects on body composition have been reported due to methodological differences [33]. This aligns with the conclusion that body composition changes are influenced not only by exercise but also by factors such as nutrition and lifestyle. Exercises targeting postural correction and muscle imbalances were highlighted to potentially lead to reductions in fat mass and increases in muscle mass. Nonetheless, the inconsistencies in the literature emphasize the need for standardized methodologies in future studies. Additionally, recent literature has emphasized the importance of integrating digital exercise models and advanced neurobiological perspectives into rehabilitation research, which broadly aligns with the multidimensional approach adopted in the present study [34, 35].

Contribution to the Literature and Limitations

In this study, a pioneering and comprehensive evaluation of Pilates' efficacy in treating FHP has been conducted, significantly enhancing the existing literature. By providing compelling evidence of Pilates' superior effects on CVA and posture compared to cervical stabilization exercises, this research fills critical gaps in understanding effective interventions for FHP. Furthermore, this study's assessment of multidimensional outcomes, including CVA, pain, ROM, body composition, quality of life, and overall posture, via the NYPRS, offers a holistic perspective on the benefits of Pilates. However, several limitations should be acknowledged.

While this study provides valuable insights, certain factors may affect the interpretation and generalizability of the findings. Although assessor blinding was rigorously implemented, participant blinding was not feasible due to the distinct nature of the exercise interventions (Pilates vs. cervical stabilization). However, the use of an independent, blinded evaluator mitigated potential measurement bias. Additionally, the physiotherapists delivering the interventions were aware of group allocations, which could theoretically introduce performance bias. To address this, standardized exercise protocols were strictly followed for both groups. Firstly, the relatively small sample size may limit the generalizability of the results to broader populations. Secondly, the absence of long-term follow-up restricts conclusions regarding the sustained effects of the observed improvements in posture, CVA, and quality of life. Thirdly, while goniometry was used for ROM assessment, future studies could benefit from the integration of more advanced biomechanical analyses, including motion capture systems or digital inclinometers, to enhance measurement precision. Lastly, further research should explore the generalizability of these findings across diverse populations, considering variations in age groups, genders, and activity levels to broaden the applicability of the results.

CONCLUSION

This study establishes Pilates as an effective intervention for improving posture, specifically the craniovertebral angle (CVA), and for alleviating neck pain in individuals with forward head posture (FHP). Notably, the findings of this study suggest that Pilates is more effective than cervical stabilization exercises in achieving these postural benefits. This research makes a notable contribution to the expanding literature on multimodal, exercise-based strategies for managing FHP, positioning Pilates as a particularly advantageous approach. To further validate and translate these findings into clinical practice, future investigations should focus on larger participant groups, longer-term follow-up assessments, and the incorporation of advanced measurement technologies to comprehensively evaluate the enduring and wider-ranging effects of Pilates and related therapeutic exercise interventions across diverse FHP populations.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper and that they have approved the final version.

Data Availability

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

Ethical Approval

This study was approved by the institutional Clinical Research Ethics Committee (Approval No: 2023-02/02; Date: 18/01/2023) and was conducted in accordance with the Declaration of Helsinki.

Consent to Participate

All participants provided written informed consent after receiving detailed explanations of the study’s purpose, procedures, and potential risks.

Consent for Publication

Written informed consent was obtained from participants and/or their legal guardians for publication of identifying information/images in an open-access publication.

Declaration of Conflicting Interest

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