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COMPARATIVE EFFECTIVENESS OF POSTURAL CORRECTION EXERCISES IN SMARTPHONE AND LAPTOP USERS WITH FORWARD HEAD POSTURE: A RANDOMIZED CONTROLLED TRIAL

Original Research

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ABSTRACT

Background: Forward Head Posture (FHP) is a common musculoskeletal deviation increasingly observed among young adults due to prolonged smartphone and laptop use. It is commonly quantified using the Craniovertebral Angle (CVA), with reduced values indicating anterior head translation. FHP is strongly associated with mechanical neck pain, decreased deep cervical flexor endurance, and functional disability. Evidence suggests that interventions targeting postural motor control may provide superior correction compared with traditional strengthening programs.

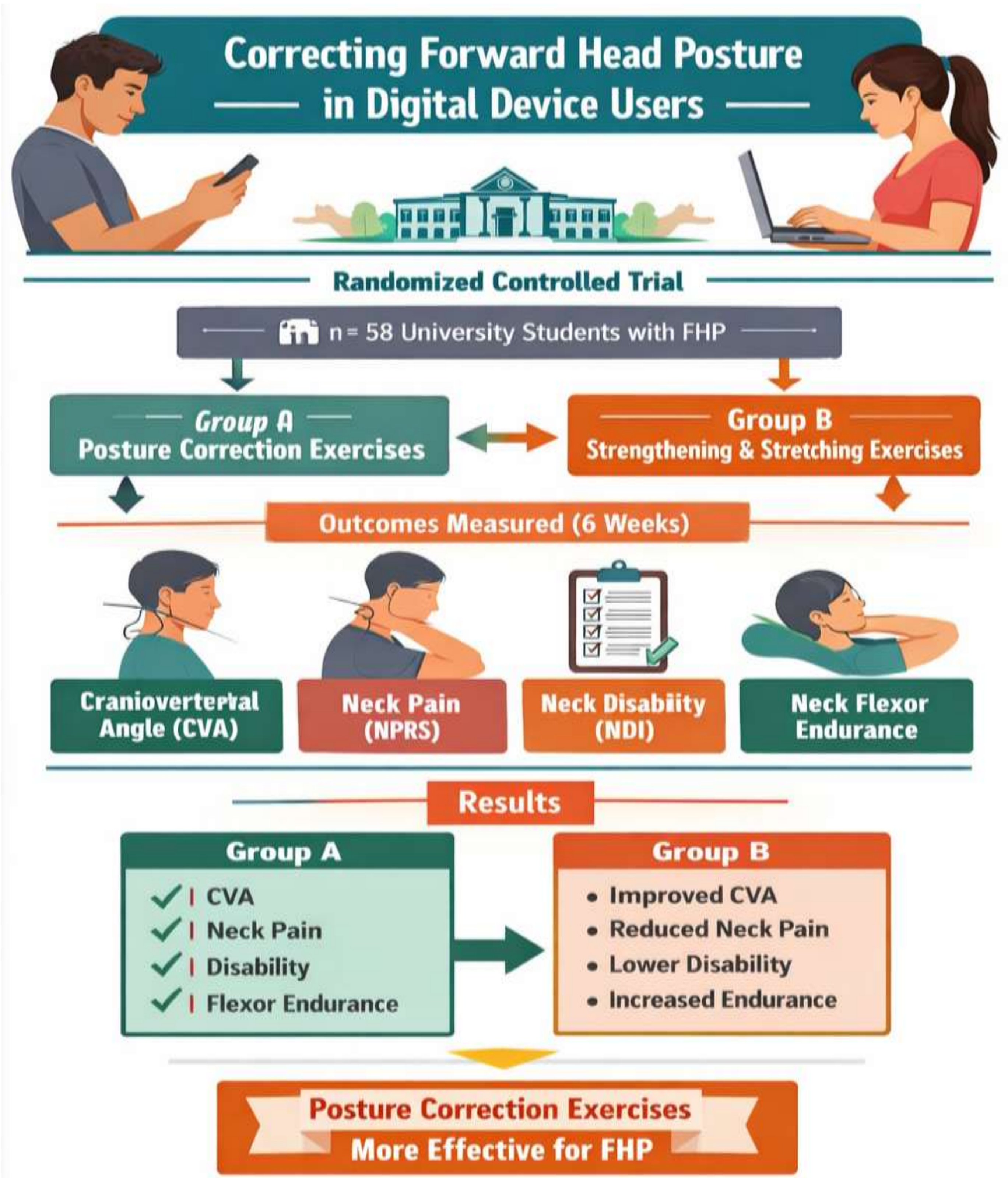
Objective: To compare the effectiveness of posture correction exercises and strengthening–stretching exercises in improving craniovertebral angle, neck pain intensity, neck disability, and deep neck flexor endurance in young adult digital device users with FHP.

Methods: This randomized controlled trial included 58 university students aged 18–25 years with clinically confirmed FHP. Participants were randomly allocated to Group A (posture correction exercises, n = 29) or Group B (strengthening–stretching exercises, n = 29). Both groups received supervised sessions three times weekly for six weeks, along with a daily home program. Outcomes were assessed at baseline, week 3, and week 6. Primary outcome was CVA. Secondary outcomes included Numeric Pain Rating Scale (NPRS), Neck Disability Index (NDI), and Deep Neck Flexor Endurance Test (DNFET). Statistical analysis was performed using independent and paired t-tests with significance set at $p < 0.05$.

Results: Baseline characteristics were comparable ($p > 0.05$). CVA improved from 47.2 ± 2.8° to 54.6 ± 2.4° in Group A and from 47.5 ± 3.0° to 52.1 ± 2.5° in Group B, with significant between-group difference at week 6 ($p < 0.01$). NPRS scores decreased from 6.2 ± 1.1 to 2.1 ± 0.9 in Group A and from 6.0 ± 1.2 to 2.9 ± 1.0 in Group B ($p < 0.01$). NDI reduced from 24.6 ± 4.8 to 11.2 ± 3.9 in Group A and from 25.1 ± 5.0 to 14.6 ± 4.2 in Group B ($p < 0.01$). DNFET improved from 18.4 ± 5.6 seconds to 34.8 ± 6.2 seconds in Group A and from 19.1 ± 5.3 seconds to 29.6 ± 5.9 seconds in Group B ($p < 0.01$).

Conclusion: Both interventions were effective; however, posture correction exercises based on motor control principles demonstrated superior improvements in cervical alignment, pain reduction, disability, and muscle endurance. These findings support the integration of posture-focused motor control strategies into rehabilitation programs for digital device users with FHP.

Keywords: Craniovertebral Angle, Forward Head Posture, Neck Pain, Postural Balance, Rehabilitation, Smartphone, Young Adult.


Correcting Forward Head Posture in Digital Device Users
Randomized Controlled Trial
n = 58 University Students with FHP
Group A
Posture Correction Exercises
Group B
Strengthening & Stretching Exercises
Outcomes Measured (6 Weeks)
Craniovertebral Angle (CVA)
Neck Pain (NPRS)
Neck Disability (NDI)
Neck Flexor Endurance
Results
Group A
CVA
Neck Pain
Disability
Flexor Endurance
Group B
Improved CVA
Reduced Neck Pain
Lower Disability
Increased Endurance
Posture Correction Exercises
More Effective for FHP

INTRODUCTION

Optimal head and neck alignment is essential for efficient load distribution across the cervical spine and for preserving neuromuscular control. In an ideal upright posture, the external auditory meatus aligns vertically over the acromion, maintaining a neutral cervical lordosis and balanced thoracic curvature, thereby minimizing excessive stress on cervical joints, discs, and surrounding soft tissues (1). Such alignment supports efficient sensorimotor integration and balanced activation between deep cervical flexors and superficial neck extensors, while coordinated thoracic and scapular control helps preserve the craniovertebral angle (CVA) and respiratory mechanics (2). Exercise-based postural retraining, particularly when combining motor-control strategies with alignment correction, has consistently demonstrated improvements in static posture and symptom reduction, and is regarded as a first-line conservative intervention in systematic reviews and meta-analyses (3). In contrast, forward head posture (FHP) represents a maladaptive anterior translation of the head relative to the trunk and has emerged as a defining musculoskeletal concern of the digital era. Prolonged smartphone and laptop use promotes sustained cervical flexion and screen-down positioning, leading to increased activation of cervical extensors and upper trapezius muscles, muscle fatigue, and cumulative mechanical loading (4–6). Epidemiological and occupational studies demonstrate a clear association between extended screen exposure and reductions in CVA, particularly among students and information technology professionals (7). The exponential rise in digital device utilization for education, communication, and recreation has fundamentally altered daily postural behaviors, contributing to muscular imbalance, altered proprioception, and difficulty sustaining neutral head alignment during prolonged tasks (8,9). Biomechanically, FHP increases anterior shear forces and posterior compressive stresses on the lower cervical segments, promoting shortening of posterior musculature and weakening of deep cervical flexors, with subsequent alteration of cervical lordosis and load-sharing patterns (5,10). The CVA, defined by the angle between a horizontal line through C7 and a line connecting C7 to the tragus, serves as a reliable quantitative measure of FHP; smaller angles reflect greater anterior head displacement and correlate strongly with neck pain severity and disability, especially in adolescents whose musculoskeletal systems remain vulnerable to mechanical stress (11).

Persistent malalignment is associated not only with reduced cervical muscle endurance and altered somatosensory responses but also with scapular dyskinesis and compromised shoulder mechanics (12). Randomized controlled trials indicate that multi-component interventions—such as postural correction combined with scapular stabilization or manual therapy integrated with stabilization exercises—produce clinically meaningful improvements in CVA and reductions in pain and disability (13). Consequently, contemporary systematic reviews advocate tailored strengthening, stretching, and motor-control programs for smartphone and laptop users presenting with FHP (3). The prevalence of FHP among frequent device users is alarmingly high, with reports ranging from 60% to 78% among young adults and students exposed to prolonged screen time (4). Cross-sectional studies consistently show that individuals exceeding three to four hours of daily device use are significantly more likely to demonstrate clinically relevant reductions in CVA and increased neck disability (5,7). Workplace investigations similarly reveal high FHP prevalence in IT professionals exposed to suboptimal workstation ergonomics (6). In Pakistan, where smartphone penetration exceeds 80%, university students represent a particularly vulnerable population, with recent surveys reporting that more than three-quarters experience device-related neck pain (14). Cultural norms favoring prolonged sitting, floor-based studying, or lounging without ergonomic support further reinforce sustained neck flexion and maladaptive postural habits (15). The etiology of FHP is multifactorial, encompassing prolonged device use, sedentary behavior, poor ergonomic environments, heavy schoolbags, psychological stress, and reduced physical activity (11). Environmental contributors such as inadequate desk height, poor lighting, and unsuitable seating amplify mechanical strain and hinder posture correction efforts (7–9). Over time, sustained anterior head positioning contributes to thoracic kyphosis, muscular imbalance, disc degeneration, and spondylotic changes, while also being associated with temporomandibular dysfunction, tension-type headaches, restricted breathing patterns, and diminished cervical mobility (11,14). Beyond structural implications, chronic neck discomfort can impair academic performance, reduce workplace productivity, and contribute to psychosocial distress, particularly among adolescents undergoing musculoskeletal maturation (8–10). Emerging evidence further links upright posture with improved mood and self-esteem, whereas slouched or forward-head alignment is associated with fatigue and depressive symptoms (11,12).

Physiotherapy offers an evidence-based, non-invasive strategy to address FHP through targeted exercises such as chin-tuck training to activate deep cervical flexors, stretching of shortened anterior musculature, and scapular stabilization to restore kinetic chain balance (12). Structured programs of six weeks or longer have demonstrated significant improvements in CVA and cervical endurance, even among asymptomatic individuals, suggesting the preventive value of early intervention (3). Educational strategies that combine ergonomic modification, device-height adjustment, micro-break scheduling, and culturally acceptable home-based exercises have shown meaningful but modest improvements when applied independently; however, greater and more sustained benefits are observed when education is integrated with structured corrective exercise regimens (15,16). In low-resource settings, barriers such as limited access to ergonomic furniture and physiotherapy services necessitate scalable solutions, including supervised home programs and digital guidance platforms (8,9). Despite the growing body of literature documenting high prevalence and biomechanical consequences of FHP, there remains a need for context-specific, structured physiotherapy protocols tailored to heavy smartphone and laptop users within culturally diverse and resource-variable populations. Particularly in Pakistani university cohorts, where device dependence is pervasive and musculoskeletal complaints are common, robust clinical investigations evaluating comprehensive corrective strategies are limited. Therefore, the present study seeks to determine whether a structured physiotherapy-based posture correction program, incorporating strengthening, stretching, stabilization, and ergonomic education, can significantly improve craniovertebral angle and reduce neck-related disability among frequent digital device users. The underlying hypothesis is that a multi-component, supervised intervention will yield clinically meaningful improvements in cervical alignment and functional outcomes compared with usual behavioral practices.

METHODS

This randomized controlled trial (RCT) was conducted to compare the effectiveness of two structured exercise interventions for correcting Forward Head Posture (FHP) among university students who were regular smartphone and laptop users. The trial was registered at ClinicalTrials.gov under registration number S23C15G30005. The study was carried out at the Institute of Health Sciences, Khyber Medical University (KMU-IHS), Matta Swat, Khyber Pakhtunkhwa, Pakistan. Ethical approval was obtained from the Institutional Review Board of Khyber Medical University prior to commencement of the study. All procedures were conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants before enrollment, and confidentiality of personal data was ensured throughout the research process. The target population comprised university students aged 18–25 years who were regular users of smartphones and/or laptops and demonstrated clinical features of FHP. Sample size estimation was performed using G*Power software version 3.1.9.7. Assuming an effect size (Cohen's d) of 0.80, a two-tailed independent t-test, an alpha level of 0.05, and statistical power of 0.80, the minimum required sample size was calculated as 52 participants. To account for a potential 10% attrition rate, the final target sample size was increased to 58 participants, with 29 participants allocated to each group. Participants were recruited through purposive sampling from the university campus and were randomly assigned to either Group A (posture correction exercises) or Group B (strengthening and stretching exercises) using a computer-generated randomization sequence. Allocation concealment was ensured using sealed opaque envelopes prepared by an independent researcher not involved in outcome assessment.

Participants were included if they were between 18 and 25 years of age, of either gender, reported regular smartphone and/or laptop use for a minimum of 2.5–3 hours daily for at least one year, and demonstrated FHP confirmed by a reduced Craniovertebral Angle (CVA). Additionally, they were required to be physically able and willing to attend three supervised sessions per week for six consecutive weeks and to comply with a daily home exercise program. Exclusion criteria included structural spinal deformities (e.g., scoliosis, kyphosis), history of cervical or thoracic spine surgery, spinal malignancy, spinal tuberculosis (Pott's disease), recent spinal fracture or trauma within the previous six months, and diagnosed neurological or systemic conditions such as Parkinson's disease, stroke, multiple sclerosis, rheumatoid arthritis, or ankylosing spondylitis. Individuals currently undergoing physical therapy or chiropractic treatment for neck or postural disorders, pregnant women, and those participating in another clinical trial were also excluded. Baseline demographic and clinical data were recorded using a structured assessment form. Postural assessment was primarily conducted using measurement of the Craniovertebral Angle (CVA), a validated and widely used parameter for quantifying FHP (17). Standardized photographic analysis was performed with participants in a relaxed standing posture. Reflective markers were placed on anatomical landmarks, specifically the tragus of the ear and the spinous process of C7. A digital mobile camera mounted on a tripod at a fixed distance and height was used to capture lateral-view photographs against a vertical reference line. The CVA was calculated as the angle formed between a horizontal line passing through C7 and a line connecting C7 to the tragus. Participants with a CVA less than or equal to 53 degrees were considered to have FHP and were eligible for recruitment (16). The CVA was subsequently measured using a goniometer and/or digital photogrammetry software to ensure measurement precision. Outcome assessments were conducted at baseline (week 0), mid-intervention (week 3), and post-intervention (week 6) by an assessor blinded to group allocation.

Both groups received supervised sessions three times per week for six weeks in addition to a structured daily home program. Each supervised session lasted approximately 45 minutes, including warm-up, therapeutic exercises, and pre-exercise modalities. Prior to exercises, participants received a hot pack application for 5–20 minutes and transcutaneous electrical nerve stimulation (TENS) for 5–10 minutes when pain was present. Group A received posture correction exercises focused on motor control, proprioception, and postural re-education. The core exercises included chin tucks, scapular setting, cervical retraction with resistance band, wall angels, and thoracic extension on a foam roller. Exercise dosage progressed systematically over six weeks by reducing external support, increasing resistance band intensity (yellow to red to green), and extending hold durations. Group B received strengthening and stretching exercises targeting muscle imbalance and flexibility restoration. Exercises included upper trapezius stretch, levator scapulae stretch, deep neck flexor strengthening (cranio-cervical flexion training), scapular retraction with resistance band (rows), and prone Y-T-W-L exercises. Dosage was progressively advanced by increasing stretch duration, resistance, and endurance holds. Both groups were prescribed simplified daily home programs lasting approximately 20–30 minutes to reinforce supervised training. Adherence was monitored through exercise logs and weekly compliance checks. Data were analyzed using Statistical Package for the Social Sciences (SPSS) version (to be specified). Descriptive statistics were calculated for demographic variables. Normality of data distribution was assessed using the Shapiro–Wilk test. Between-group comparisons were performed using independent samples t-tests for normally distributed data, while within-group changes across time points were analyzed using paired t-tests or repeated measures ANOVA as appropriate. A p-value of less than 0.05 was considered statistically significant. Effect sizes were calculated to determine the magnitude of treatment effects.

RESULTS

A total of 58 participants completed the trial, with 29 participants allocated to each intervention group. The age distribution was comparable between groups. In Group A, 11 participants (37.9%) were aged 18–20 years, 12 (41.4%) were aged 21–23 years, and 6 (20.7%) were aged 24–25 years. In Group B, 10 participants (34.5%) were aged 18–20 years, 13 (44.8%) were aged 21–23 years, and 6 (20.7%) were aged 24–25 years. Overall, the largest proportion of participants belonged to the 21–23-year age group (43.1%), followed by the 18–20-year group (36.2%) and the 24–25-year group (20.7%). Gender distribution was also balanced between the groups. Group A comprised 15 males (51.7%) and 14 females (48.3%), while Group B included 16 males (55.2%) and 13 females (44.8%). Overall, 31 participants (53.4%) were male and 27 (46.6%) were female. Baseline demographic and device-use characteristics showed no statistically significant differences between the groups ($p > 0.05$). The mean age was 21.3 ± 2.1 years in Group A and 21.6 ± 2.0 years in Group B. The average daily screen time was 4.6 ± 1.1 hours in Group A and 4.7 ± 1.2 hours in Group B. These findings indicated baseline comparability following randomization. For the primary outcome, craniovertebral angle (CVA), both groups demonstrated similar baseline values, with Group A at 47.2 ± 2.8° and Group B at 47.5 ± 3.0° ($p > 0.05$). At mid-intervention (Week 3), CVA increased to 50.8 ± 2.6° in Group A and 49.3 ± 2.7° in Group B, with a statistically significant between-group difference ($p < 0.05$). By Week 6, further improvement was observed in both groups, with Group A reaching 54.6 ± 2.4° and Group B 52.1 ± 2.5°. The between-group difference at Week 6 was highly significant ($p < 0.01$). The mean improvement from baseline to Week 6 was 7.4° in Group A and 4.6° in Group B.

Regarding neck pain intensity measured using the Numeric Pain Rating Scale (NPRS), baseline values were comparable (Group A: 6.2 ± 1.1; Group B: 6.0 ± 1.2; $p > 0.05$). At Week 3, pain scores decreased to 3.8 ± 1.0 in Group A and 4.4 ± 1.1 in Group B ($p < 0.05$). By Week 6, pain further reduced to 2.1 ± 0.9 in Group A and 2.9 ± 1.0 in Group B ($p < 0.01$). The absolute reduction in NPRS from baseline to Week 6 was 4.1 points in Group A and 3.1 points in Group B. Neck disability, measured using the Neck Disability Index (NDI), was similar at baseline (Group A: 24.6 ± 4.8; Group B: 25.1 ± 5.0; $p > 0.05$). At Week 6, NDI scores decreased to 11.2 ± 3.9 in Group A and 14.6 ± 4.2 in Group B, demonstrating a highly significant between-group difference ($p < 0.01$). The mean reduction in disability was 13.4 points in Group A compared to 10.5 points in Group B. Deep neck flexor endurance, assessed using the Deep Neck Flexor Endurance Test (DNFET), was comparable at baseline (Group A: 18.4 ± 5.6 seconds; Group B: 19.1 ± 5.3 seconds; $p > 0.05$). At Week 6, endurance improved to 34.8 ± 6.2 seconds in Group A and 29.6 ± 5.9 seconds in Group B ($p < 0.01$). The mean increase in endurance was 16.4 seconds in Group A and 10.5 seconds in Group B. Overall, both interventions resulted in statistically significant within-group improvements across all primary and secondary outcomes; however, the magnitude of improvement was consistently greater in Group A across CVA, NPRS, NDI, and DNFET outcomes.

Table 1: Age-wise Distribution of Participants (n = 58)

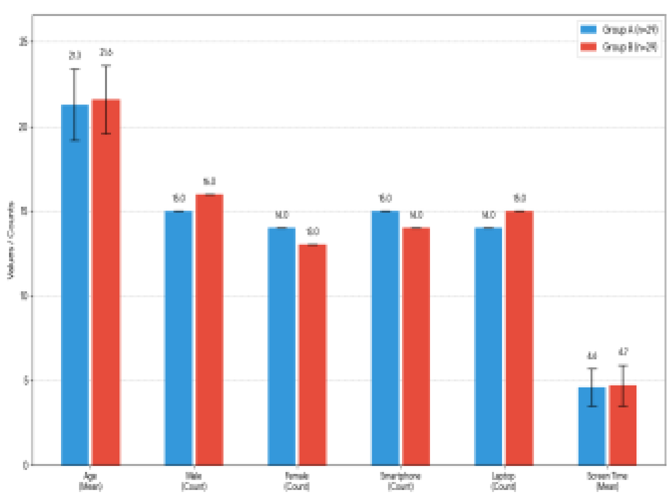
Age Group (years)	Group A (n = 29) n (%)	Group B (n = 29) n (%)	Total n (%)
18–20	11 (37.9)	10 (34.5)	21 (36.2)
21–23	12 (41.4)	13 (44.8)	25 (43.1)
24–25	6 (20.7)	6 (20.7)	12 (20.7)

Table 2: Gender-wise Distribution of Participants (n = 58)

Gender	Group A (n = 29) n (%)	Group B (n = 29) n (%)	Total n (%)
Male	15 (51.7)	16 (55.2)	31 (53.4)
Female	14 (48.3)	13 (44.8)	27 (46.6)

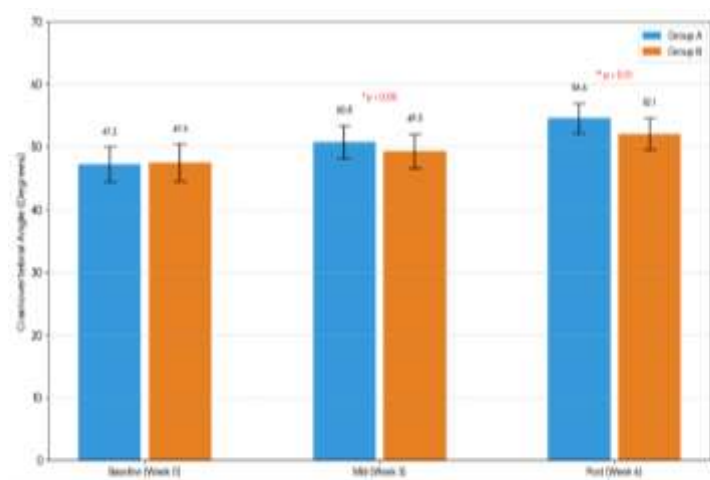
Table 3: Comparison of Deep Neck Flexor Endurance (seconds) Between Groups

Time Point	Group A Mean ± SD	Group B Mean ± SD	p-value
Baseline	18.4 ± 5.6	19.1 ± 5.3	>0.05
Post (Week 6)	34.8 ± 6.2	29.6 ± 5.9	<0.01



Baseline Demographic and Device-Use Characteristics of Participants

Figure 1 Baseline Demographic and Device use Chart eristics of Participants



Comparison of Craniovertebral Angle (degrees) Between Groups Across Time

Figure 1 Comparison of Craniovertebral Angle Between Groups Across Time

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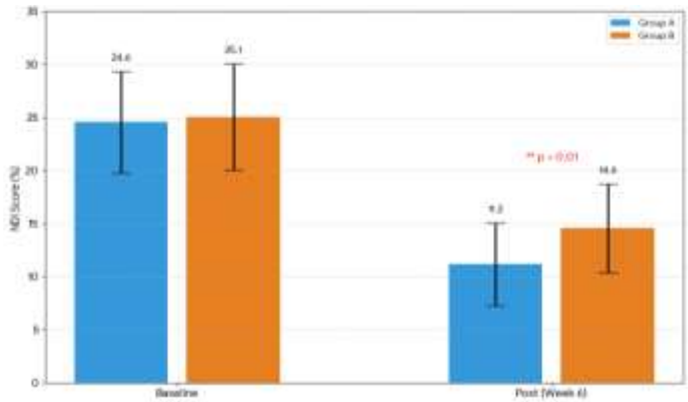

Comparison of Neck Disability Index (NDI) Scores Between Groups

Figure 3 Comparison of Neck Disability Index (NDI) Scores Between Groups

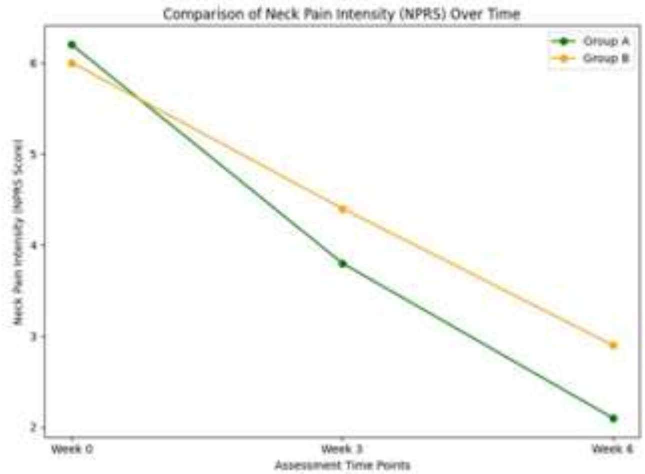

Figure 2 Comparison of Neck Pain Intensity (NPRS) Over Time

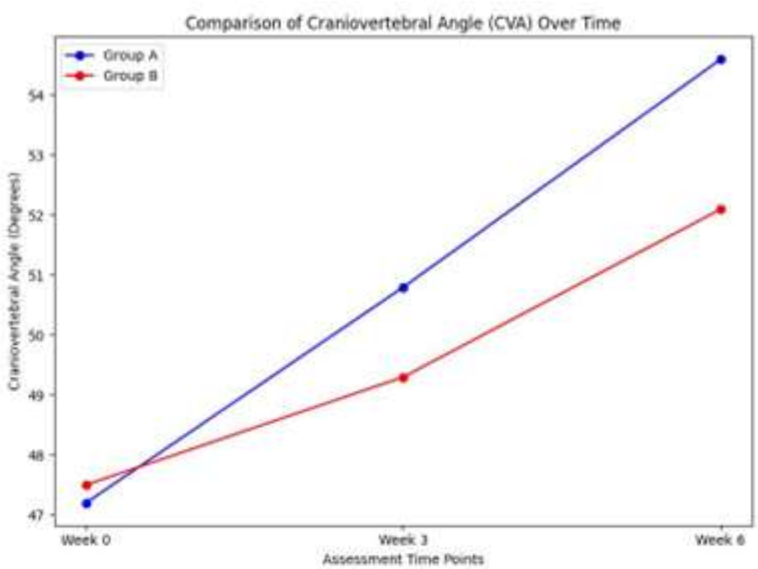

Figure 5 Comparison of Craniovertebral Angle (CVA) Over Time

DISCUSSION

The present randomized controlled trial evaluated the comparative effectiveness of motor control–based posture correction exercises and conventional strengthening and stretching exercises in improving forward head posture (FHP) among smartphone and laptop users. The findings demonstrated that although both interventions produced statistically significant improvements in craniovertebral angle (CVA), neck pain intensity, neck disability, and deep neck flexor endurance, the motor control–oriented posture correction program yielded consistently superior outcomes across all measured variables. These results support the hypothesis that interventions specifically targeting postural alignment and neuromuscular retraining provide greater therapeutic benefit than programs focusing primarily on muscle length and strength restoration alone. The most notable finding was the significantly greater improvement in CVA in the posture correction group. Both groups began with comparable baseline CVA values of approximately 47°, indicating moderate to severe FHP. After six weeks, CVA increased to 54.6° in the motor control group compared with 52.1° in the strengthening–stretching group, with a highly significant between-group difference. This magnitude of improvement suggests not merely symptomatic relief but meaningful structural and postural correction. Previous randomized trials have reported similar findings, demonstrating that cervical retraction exercises and postural awareness training significantly enhance head alignment compared with generalized strengthening programs (12). Other investigations have shown that neuromuscular retraining of deep cervical flexors results in superior postural normalization relative to nonspecific exercise regimens (13). Systematic reviews and meta-analyses have further reinforced that programs incorporating postural re-education achieve larger and more durable gains in CVA compared with muscle-based approaches alone. The greater effectiveness of the motor control protocol can be understood through its emphasis on task-specific retraining. Exercises such as chin tucks, wall alignment drills, and resisted cervical retraction directly addressed faulty head positioning while enhancing proprioceptive feedback and sensorimotor integration. This approach likely facilitated the re-establishment of optimal neuromuscular activation patterns and habitual alignment during functional activities. In contrast, although stretching and strengthening exercises addressed muscular imbalance, they may not have sufficiently targeted the habitual anterior head translation reinforced during prolonged device use. Emerging biomechanical and kinematic research has emphasized that correcting movement patterns and postural awareness is essential for sustained alignment correction in digital device users.

Both groups experienced substantial reductions in neck pain intensity; however, the reduction was significantly greater and more rapid in the motor control group. Pain scores declined from 6.2 to 2.1 in the posture correction group compared with a reduction from 6.0 to 2.9 in the strengthening–stretching group. The relationship between FHP and mechanical neck pain is well documented, with anterior head displacement increasing extensor muscle overactivity and compressive loading on cervical structures (14). Restoration of neutral alignment likely reduced abnormal joint stress and nociceptive input, thereby contributing to superior analgesic effects. Previous trials have similarly demonstrated that exercises emphasizing cervical control and posture correction provide greater pain relief than strengthening exercises alone (15,16). Interventions centered on chin-tuck–based retraining have also shown clinically meaningful pain reduction within six weeks among smartphone users (15). Enhanced sensorimotor control and decreased overactivation of superficial cervical extensors and upper trapezius muscles may have further contributed to the improved pain outcomes observed in the motor control group (16). Neck disability outcomes mirrored improvements in posture and pain. Both groups demonstrated significant reductions in Neck Disability Index (NDI) scores; however, the improvement exceeded 50% in the motor control group compared with approximately 42% in the strengthening–stretching group. This functional improvement aligns with prior randomized studies indicating that enhanced postural alignment is closely associated with improved daily function and reduced activity limitations (17). Research examining deep cervical flexor retraining has reported meaningful reductions in disability scores in individuals with chronic neck pain (18). A systematic review also highlighted that exercise programs integrating postural education and motor control yield clinically significant reductions in disability when compared with isolated strengthening protocols (19). The functional gains observed in the current trial likely reflected the combined effects of alignment correction, pain reduction, and improved neuromuscular coordination.

Deep neck flexor endurance improved in both groups, with a significantly greater increase in the motor control group (34.8 seconds versus 29.6 seconds at post-intervention). Motor control–based exercises have been shown to selectively activate the longus colli and longus capitis muscles, enhancing both activation efficiency and endurance capacity (20). Controlled retraining programs have previously demonstrated superior improvements in deep cervical flexor endurance compared with general strengthening exercises (21). Given the established association between reduced deep neck flexor endurance, FHP, and neck pain, this improvement holds clinical relevance for sustained postural maintenance during prolonged device use. The device-specific context of the study also merits consideration. Smartphone users frequently adopt greater cervical flexion angles and sustained downward gaze compared with laptop users, leading to higher cervical loads (22). Previous kinematic analyses have demonstrated that corrective exercise interventions may yield more pronounced alignment improvements in smartphone users due to the greater baseline mechanical stress associated with handheld device use (23). The current findings support the need for device-informed rehabilitation strategies tailored to habitual use patterns. The study possessed several strengths. It employed a randomized controlled design with clearly defined inclusion criteria and standardized outcome measures. Baseline comparability between groups strengthened internal validity, and multiple outcome domains—including structural alignment, pain, disability, and muscle endurance—were assessed to provide a comprehensive evaluation of intervention effects. The structured progression of exercises and supervised sessions enhanced adherence and intervention fidelity.

Nevertheless, certain limitations warrant acknowledgment. The intervention period was limited to six weeks, and the absence of long-term follow-up precluded assessment of sustained effects. The relatively small and homogeneous sample of university students limited generalizability to broader age groups and occupational populations. Reliance on self-reported measures such as NPRS and NDI may have introduced response bias. Additionally, the study did not include objective biomechanical or electromyographic analyses to further elucidate neuromuscular mechanisms underlying improvement. Reporting of long-term adherence and potential relapse rates would strengthen understanding of sustainability. Future research should incorporate larger, more diverse populations and extend follow-up durations to determine the durability of motor control–based interventions. Integration of objective biomechanical assessments, motion analysis, and electromyography would clarify mechanistic pathways. Comparative trials exploring hybrid protocols that combine motor control retraining with ergonomic modifications or digital posture feedback technologies may further optimize outcomes. Investigation into preventive strategies among adolescents and high-risk occupational groups would also contribute to reducing the long-term burden of FHP. Overall, the present findings provide clinically meaningful evidence that motor control–based posture correction exercises offer superior benefits over traditional strengthening and stretching approaches for improving craniovertebral alignment, reducing pain, decreasing disability, and enhancing deep neck flexor endurance in digital device users. These results reinforce contemporary models of postural rehabilitation that prioritize neuromuscular retraining and movement pattern correction as central mechanisms for sustainable improvement.

CONCLUSION

This randomized controlled trial concluded that while both posture correction exercises and general strengthening–stretching programs were beneficial in improving forward head posture among young adult smartphone and laptop users, posture correction exercises grounded in motor control and neuromuscular re-education produced superior overall outcomes. The findings reinforce the understanding that forward head posture is not merely a consequence of muscle imbalance, but largely a dysfunction of habitual movement patterns and impaired postural awareness. Interventions that directly retrain alignment, proprioception, and coordinated muscle activation appear to offer more meaningful and comprehensive rehabilitation benefits. These results highlight the importance of integrating posture-focused, device-specific rehabilitation strategies into clinical physiotherapy practice to address the growing burden of technology-related cervical dysfunction and to promote long-term musculoskeletal health.

AUTHOR CONTRIBUTIONS

Author	Contribution
Hafsa Rahim*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Wagma Wajid	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Huma Zia	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Zakir Ullah	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Alla Ud Din	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Suraya Rehmat	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Shayan Ahmed	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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