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EXPERIMENTAL EVIDENCE ON DEVICE SPECIFIC RESPONSE TO POSTURE CORRECTION EXERCISES

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Abstract

Background: *Abnormal head posture specifically forward Head Posture, commonly assessed via the Craniovertebral Angle (CVA), is a prevalent postural dysfunction linked to prolonged smartphone and laptop use, often resulting in neck pain and disability.*

Objective: *This study compared the effectiveness of posture correction exercises versus strengthening/stretching exercises on CVA, neck pain, disability, and deep neck flexor endurance in device users.*

Methods: *In this randomized controlled trial, 58 university students with FHP were allocated to Group A (posture correction exercises, n=29) or Group B (strengthening/stretching exercises, n=29). Both groups performed supervised sessions three times weekly for six weeks. Outcomes (CVA, pain, disability, endurance) were measured at baseline, week 3, and week 6.*

Results: *Baseline demographic and clinical characteristics did not differ significantly between the two groups ($p > 0.05$). Both interventions produced statistically significant improvements across all outcome variables over time. However, Group A demonstrated a markedly greater enhancement in craniovertebral angle at both the mid-intervention and post-intervention assessments compared to Group B ($p < 0.05$), indicating superior correction of forward head posture. Significant reductions in neck pain intensity and neck disability were observed in both groups, although the magnitude of improvement was consistently higher in Group A ($p < 0.05$). Deep neck flexor endurance also improved significantly in both groups, with Group A showing a more pronounced increase.*

Conclusion: *Posture correction exercises demonstrated superior outcomes, particularly in improving craniovertebral angle and functional measures. However, both posture correction exercises and strengthening and stretching exercises are effective in improving forward head posture, reducing neck pain, decreasing disability, and enhancing deep neck flexor endurance among smartphone and laptop users. These findings support the use of posture-focused*

motor control exercises as a preferred intervention for managing forward head posture in young adult digital device users.

Introduction: Correct posture requires the ears to lie vertically over the acromion with a neutral cervical lordosis and balanced thoracic alignment, which minimizes abnormal loading on cervical structures (1). Maintaining neutral head position preserves efficient sensorimotor integration and reduces maladaptive muscle synergies between deep cervical flexors and superficial neck extensors. Regular postural awareness combined with thoracic and scapular control helps maintain cranio-vertebral angle and respiratory mechanics (2). Supervised exercise programs that combine motor-control and alignment training consistently improve static alignment in adults. Systematic reviews support exercise-based correction as an evidence-based first-line strategy for postural retraining (3).

Forward Head Posture in the Digital Era: Forward head posture (FHP) describes an anterior translation of the head relative to the trunk and is strongly associated with prolonged device use (smartphones/laptops) and sustained neck flexion angles (4). Kinematic and EMG studies show increased cervical extensor and upper-trapezius activity with device texting and screen-down laptop use, which increases muscle fatigue and symptomatic loading (5, 6). Epidemiologic and workplace studies link FHP magnitude to duration of screen exposure and to reductions in cranio-vertebral angle (CVA) in IT and student populations (7). Device-specific ergonomics (screen height, keyboard angle) plus corrective exercises reduce the positional bias toward FHP (8). With the rapid growth of digital technology, individuals now spend extended hours each day on smartphones, laptops, and other electronic devices for communication, education, entertainment, and social interaction (9). This behavioral change has brought about, among other factors, changes in neck posture and muscular imbalance. Many computer users also show reduced proprioceptive sensitivity of the neck, making it difficult to maintain the head in the correct position for extended computer use periods (10).

Biomechanics and Anatomical Implications of FHP: It biomechanically increases anterior shear and posterior compressive forces on lower cervical facets, thus shortening posterior musculature and lengthening/weakening deep cervical flexors, which alters cervical lordosis and load distribution (11, 12). One of the most commonly used quantitative measures for assessing FHP is the Craniovertebral Angle (CVA). It is measured by the angle between a horizontal line passing through the C7 spinous process and a line joining the tragus of the ear. The more forward the head, the smaller the CVA value. CVA is strongly associated with increasing levels of neck pain and discomfort. This relationship is particularly evident in adolescents, whose musculoskeletal systems are still developing and more vulnerable to the mechanical stress imposed by poor posture (13). These spinal and muscular changes are associated with higher neck disability, altered somatosensory evoked potentials, and reduced cervical muscle endurance in symptomatic and some asymptomatic adults (1, 14). The biomechanical alignment of the spine, in turn, directly influences the functioning of the shoulder girdle and scapular mechanics. Whenever there is a sustained anterior positioning of the head, the musculature of the anterior neck and shoulder muscles tends to shorten, while the posterior cervical extensors elongate and weaken. This sets off a chain reaction in the scapula, leading to compensatory movements, muscle fatigue, and altered movement patterns in the upper body (13). Randomized trials and RCTs prove that multi-component treatments such as postural correction + scapular stabilization or manual therapy + stabilization exercise—yield clinically meaningful CVA improvements and pain/disability reduction (15, 16). Meta-analysis and recent systematic reviews thus recommend tailored strengthening/stretching + motor-control programs among smartphone and laptop users presenting with FHP (3).

Prevalence of Forward Head Posture: FHP is very common among frequent smartphone and laptop users, with various population-based studies reporting 60-78% prevalence rates in young adults and students with prolonged screen exposure (4). Many studies have noted that individuals commonly assume a forward neck posture during the use of handheld devices, leading to sustained cervical flexion that promotes the progression of FHP (17). Greater daily smartphone use duration and habitual neck flexion angles correlate highly with a decreased craniovertebral angle, reflecting higher FHP prevalence (5). Recent cross-sectional studies among university students also reveal that over half of the device users present clinically significant FHP, particularly those who exceed 3-4 hours of screen time per day (7). Workplace-based studies among IT professionals also reflect high FHP prevalence associated with extended laptop use and poor workstation ergonomics (6).

Contributory Factors: The development of FHP is multifactorial and influenced by a combination of lifestyle, ergonomic, and psychosocial factors, including the following: Prolonged and repeated use of smartphones, laptops, and tablets (18) Sedentary habits and poor sitting ergonomics (19) Heavy schoolbags or poor workstation setup (20) Psychological stress, anxiety, and less physical activity (21) In Pakistan, the use of smartphones has increased exponentially, with the national penetration rates of more than 80%. Young adults, in particular university students, are the most common group repeatedly exposed to these risk factors for their academic, social, and recreational screen time (22). Recent studies reported that more than three-quarters of Pakistani university students experience neck pain related to the use of smartphones (23). Prolonged mobile gaming/device use (with sustained neck flexion) is associated with higher incidence of FHP among young adults (24). Cultural norms and the surrounding environment are important in posture habits, especially when comparing the effectiveness of posture correction exercises for FHP among smartphone and laptop users. In many societies, heavy reliance on digital devices is often adopted in sitting or lounging postures without ergonomic support, reflecting a cultural shift toward sedentary, screen-based lifestyles that predispose individuals to sustained forward head tilt and spinal flexion (25). For example, a large cross-sectional survey found that prolonged smartphone use was strongly associated with FHP and neck disability among college students. Prolonged use of smartphones has been strongly associated with FHP and neck disability among college students (26).

Literature Review: These posture deviations are further accentuated by environmental factors such as non-ergonomic furniture, poor workspace ergonomics, and inadequate back support (27). The habitual nature of device use, many hours a day, in culturally accepted postures such as sitting on the floor or lounging on sofas, reinforces maladaptive posture over time and makes corrective measures more difficult (28). Awareness about ergonomics and musculoskeletal health in a cultural context also plays a role in the adoption and adherence to posture correction exercises. Thus, posture correction programs should take both cultural behaviors and environmental settings into consideration to achieve better results. Poor lighting, inappropriate desk height, and unsuitable seating are some of the more common environmental contributors to forward head posture (29). Interventions that include culturally acceptable exercises combined with an ergonomically optimized environment can result in significant improvements in posture. Thus, any attempt to address FHP among users of smartphones and laptops must be holistic, combining both behavioral and environmental modification. Physiotherapy provides an effective, evidence-based approach for the correction and management of FHP (31). Through targeted therapeutic exercises, physiotherapists aim to restore muscular balance, improve cervical alignment, and promote postural re-education. Key exercises that form the cornerstone of physiotherapy management include: Chin tuck exercises: Strengthen deep cervical flexor muscles, enhance proprioceptive control, and help maintain neutral head alignment (32). Physiotherapy management of FHP focuses on targeted posture correction exercises, strengthening of deep cervical flexors, stretching

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of overactive musculature, and, when necessary, scapular stabilization to restore optimal head-neck alignment and improve cervical function. For example, a 6-week home-based program of deep cervical flexor training demonstrated significant improvement in craniovertebral angle and increased deep flexor endurance even in asymptomatic individuals, suggesting early intervention can prevent future neck dysfunction. Additionally, posture correction exercises, when combined with scapular stabilization exercises and adjuncts like kinesio-taping, have shown better gains in the CVA, scapular position, and even dominant hand grip strength in subjects with FHP 8. Systematic reviews and meta-analyses support the efficacy of therapeutic exercises in general by demonstrating significant enhancement in posture parameters, for example, CVA, and pain intensity reduction (33). In individuals with chronic "tech neck" from smartphone and laptop use, regular modified cervical exercises, such as chin tuck, neck flexion/extension, and postural awareness routines, can counteract forward head displacement and related muscle imbalance by restoring more neutral alignment over a few weeks (3). Considering the very high prevalence of FHP in users of devices, the implementation of a structured physiotherapy program that combines strengthening, stretching, stabilization, and posture education adds up to an evidence-based, non-invasive means of mitigating neck strain and preventing long-term musculoskeletal dysfunction. Clinically, individuals with FHP often report neck pain, stiffness, reduced neck mobility, and cervicogenic headaches; some also experience neuropathic symptoms and restricted range of motion in cervical joints (10). Prolonged static flexed neck position, common among smartphone/laptop users, is also associated with altered spinal alignment — increased thoracic kyphosis, imbalance between deep neck flexors and extensors, and possible compensatory changes in thoracic posture (11). From a clinical perspective, FHP can lead to a range of musculoskeletal impairments and dysfunctions, including, Reduced cervical range of motion and stiffness, Decreased endurance of deep cervical flexors, Increased activation of superficial neck muscles and Altered scapular motion and shoulder mechanics (12). Radiological findings have shown that persistent FHP contributes to the reduction of cervical lordosis, degeneration of intervertebral discs, and spondylotic changes in the vertebral column . Moreover, shortened sternocleidomastoid and suboccipital muscles combined with weakened deep neck flexors create a cycle of imbalance, dysfunction, and pain Besides, FHP has been related to temporomandibular joint dysfunction, tension-type headaches and restricted breathing due to limited thoracic mobility and postural stiffness (14). Beyond the physical, FHP also has significant psychosocial and functional implications. People with chronic neck pain face loss of work efficiency, absenteeism, and poor academic performance. Chronic musculoskeletal discomfort is also associated with emotional disturbances such as anxiety, stress, and low self-esteem (38).Adolescents are particularly vulnerable due to their continuing growth and musculoskeletal maturation. During this period, habitual poor postures can cause permanent changes in spinal alignment and muscle tone (39). Longitudinal studies have indicated that adolescents who display severe FHP are more prone to chronic neck and shoulder disorders as adults (40). Moreover, posture is linked with the emotional state; erect postures are associated with enhanced self-esteem, alertness, and mood stability, while slouched or forward-head positions are associated with fatigue, depressive states, and reduced motivation (41), (42). The pattern of smartphone and computer use in Pakistan closely parallels that of other technologically active countries. Research conducted in Karachi reported almost 75% of university students with neck and shoulder pain related to smartphone use. FHP is a growing concern throughout Pakistan, primarily because of excessive smartphone and laptop use by students, IT professionals, and young adults (23). Several cross-sectional surveys have reported high prevalence rates ~ for example, ~64% in university students; ~70-84% in cohorts using these devices ~and strong associations between a reduced CVA and device use or neck disability (43). Occupational and specialty samples, such as sewing machine operators, carpenters, and freelancers, also demonstrate high FHP prevalence, indicating the problem extends across both sedentary and manual worker groups (13). Recent methodological work from Pakistani centers has improved reliability of CVA measurement for epidemiologic surveillance (14). Preventive and educational strategies are among the most effective tools for reducing the occurrence of FHP. Recommended ergonomic measures include, Raising digital devices to eye level to minimize neck flexion, Using lumbar and back support to maintain spinal alignment, Taking frequent breaks during study or work sessions, Implementing posture awareness and exercise education programs (15). Preventive and educational approaches are central to reducing the burden of forward head posture (FHP) among heavy smartphone and laptop users by combining simple posture-awareness training, ergonomic adjustments, and brief daily corrective exercises that target deep cervical flexors, scapular retractors and pectoral stretches. Education (postural guidelines, device-height adjustments, and scheduled micro-breaks) raises awareness and can produce small but meaningful CVA improvements on its own (16). while structured corrective exercise programs (chin-tuck/deep-neck-flexor training, stretching of shortened anterior chest muscles, scapular stabilization) consistently yield larger and more reliable increases in craniovertebral angle and reductions in neck pain (3). Low-income countries make it difficult for the implementation of posture correction initiatives. In such countries, people cannot afford ergonomic furniture, and physiotherapy is not readily available (48). Repetitive home exercises and online assistance, such as video assistance, video guidance, and text guidance for use with smartphones, were successful and helped correct posture within weeks with consistent following (8). To overcome these challenges, initiatives by the community and teaching about proper posture in schools can greatly influence spine health and correct postures in young individuals.

Materials and Methods

Study Design: This study was conducted as Randomized Controlled Trial (RCT) and this trial is registered in **clinicaltrials.gov** under the registration number **S23C15G30005**. RCT design is used to compare the effectiveness of two exercise interventions for correcting Forward Head Posture (FHP) in smartphone and laptop users.

Study Setting: The current RCT was conducted at Khyber Medical University, Institute of Health Sciences (KMU-IHS), Matta Swat, Khyber Pakhtunkhwa, Pakistan.

Target population: The target population consists of university students aged 18–25 years who are regular users of smartphones and laptops and exhibit Forward Head Posture.

Sample Size: Sample size calculation was performed by the G Power software, Version 3.1.9.7. With an effect size of Cohen's d = 0.80, an alpha (α) level of 0.05, and a power (1-β) of 0.80, considering a two-tailed independent t-test design, the minimum sample size estimated for this work was 52 participants. Given the likelihood of a 10% dropout rate, the target sample is 58 participants, with 29 participants per group.

Inclusion Criteria: Participants were eligible for the study if they met all the following conditions: they were between 18 and 25 years of age, of any gender, and reported regular use of either a smartphone, laptop, or both for a minimum of 2.5 to 3 hours daily for at least the past year. A clinical diagnosis of Forward Head Posture (FHP), confirmed by a reduced Craniovertebral Angle (CVA) measurement, was required. Furthermore, eligible participants needed to be able and willing to attend three supervised exercise sessions per week for six consecutive weeks at the KMU-IHS Swat facility and to provide written informed consent.

Exclusion Criteria: Participants were excluded from the study if they presented with any of the following: structural spinal conditions such as congenital or acquired deformities (e.g., scoliosis, kyphosis); a history of cervical or thoracic spine surgery, spinal malignancy, or Potts disease (spinal tuberculosis); or a recent spinal fracture or trauma within the past six months. Additional exclusions comprised diagnosed neurological or systemic conditions (e.g., Parkinson's disease, stroke, multiple sclerosis, rheumatoid arthritis, or ankylosing spondylitis). Individuals currently receiving physical therapy or chiropractic care for neck or postural issues, those who were pregnant, or those concurrently participating in another clinical trial were also excluded.

Data Collection Tools: Validated tools and instruments were used to collect data for this study, ensuring comprehensive assessment of postural, clinical, and functional outcomes. For postural evaluation, the Craniovertebral Angle (CVA) were measured using a standardized photographic method with a mobile camera mounted on a tripod, reflective markers placed on anatomical landmarks (tragus of the ear and C7 spinous process), and a plumb line or gridded backdrop to maintain a consistent vertical reference CVA were asses through photographometery analysis if the CVA was less than or equal to 53 degrees they were recruited within the trial (18).

The craniovertebral angle (CVA) was measured using a goniometer. A CVA angle less than 48° was considered indicative of forward head posture.

Intervention Protocols

Therapeutic Focus	Motor control, proprioception, postural re-education	Muscle balance, flexibility, strength restoration
Session Duration	45 minutes	45 minutes
Frequency	3x/week supervised + daily home program	3x/week supervised + daily home program
Pre-Exercise Modalities	Hot pack (15–20 min) + TENS (10 min)	Hot pack (15–20 min) + TENS (10 min)
Core Exercises	1. Chin Tucks	1. Upper Trapezius Stretch

	2. Scapular Setting	2. Levator Scapulae Stretch
	3. Cervical Retraction with Band	3. Deep Neck Flexor Strengthening
	4. Wall Angels	4. Band Rows
	5. Thoracic Extension on Foam Roller	5. Pectoral Stretch
		6. Prone Y-T-W-L
Equipment Used	Resistance bands, foam roller, wall	Resistance bands, doorway, exercise mat
Progression Method	Reduce external support (wall → free), increase band resistance, increase hold duration	Increase stretch duration, increase band resistance, add endurance holds
Home Program	Simplified daily circuit (15–20 min) focusing on alignment	Simplified daily circuit (15–20 min) focusing on stretching & strengthening

Detailed Exercise Protocol and Dosage

Exercise	Group	Starting Dosage (Weeks 1–2)	Progression (Weeks 3–4)	Advanced (Weeks 5–6)
Chin Tucks	A	3×10 reps, 5s hold (against wall)	3×10 reps, 5s hold (free sitting)	3×10 reps, 7s hold (+light finger resistance)
Scapular Setting	A	3×12 reps, 5s hold	3×12 reps, 7s hold	3×12 reps, 10s hold
Cervical Retraction with Band	A	3×10 reps (Yellow band)	3×10 reps (Red band)	3×10 reps (Green band)
Wall Angels	A	3×8 reps (partial range)	3×10 reps (full range)	3×12 reps (+2s hold at top)
Upper Trapezius Stretch	B	3×25s hold/side	3×30s hold/side	3×35s hold/side
Levator Scapulae Stretch	B	3×25s hold/side	3×30s hold/side	3×35s hold/side
Deep Neck Flexor Strengthening	B	3×8 holds (5s)	3×10 holds (7s)	3×10 holds (10s)
Band Rows	B	3×12 reps (Yellow band)	3×15 reps (Red band)	3×15 reps (Green band)
Prone Y-T-W-L	B	2×6 reps/letter	2×8 reps/letter	2×8 reps/letter (+1s hold)

Intervention/Protocol

Parameter	**Group A (posture correction exercises)**	**Group B (Strengthening & Stretching Exercises)**
Session Duration	10-15 minutes per session	10-15 minutes per session
Frequency	3 sessions/week for 6 weeks + daily home program	3 sessions/week for 6 weeks + daily home program
Warm up (5-7minutes)	Gentle neck and shoulder movements, scapular circles, wall alignment warm-up	Gentle neck ROM exercises, light scapular mobility movements
Main exercises	Chin Tucks – 3 × 10 reps (5 s hold)Cervical Retraction with	Upper Trapezius Stretch – 3 × 30 s each sideLevator Scapulae

	Resistance Band – 3 × 10 slow controlled repsShoulder Blade Squeeze (Seated) – 3 × 12 (5 s hold)Wall Posture Alignment / Wall Angel – 3 × 10	Stretch – 3 × 30 s each sidedeep neck flexor strengthening (Cranio-Cervical Flexion) – 3 × 10 holds (5–10 s)Scapular Retraction with Resistance Band (Rows) – 3 × 10–15
Modalities	Hot Pack (5–10 min pre-exercise); TENS for pain (5-7 min if needed)	Hot Pack (5–10 min pre-exercise); TENS for pain (5-7 min if needed)
Tool/Equipment	TheraBand (resistance band), TENS unit, Hot Pack.	TheraBand, TENS unit, Hot Pack, Measuring Tape for ROM.
Home exercise plan	Daily 20–30 min: Chin Tucks, Scapular Squeeze, Wall Alignment	Daily 20–30 min: Upper Trapezius & Levator Scapulae Stretch, Deep Neck Flexor Training, Band Rows
Assessment Timeline	Baseline (week 0), Mid (week 3), Post (week 6)	Baseline (week 0), Mid (week 3), Post (week 6)

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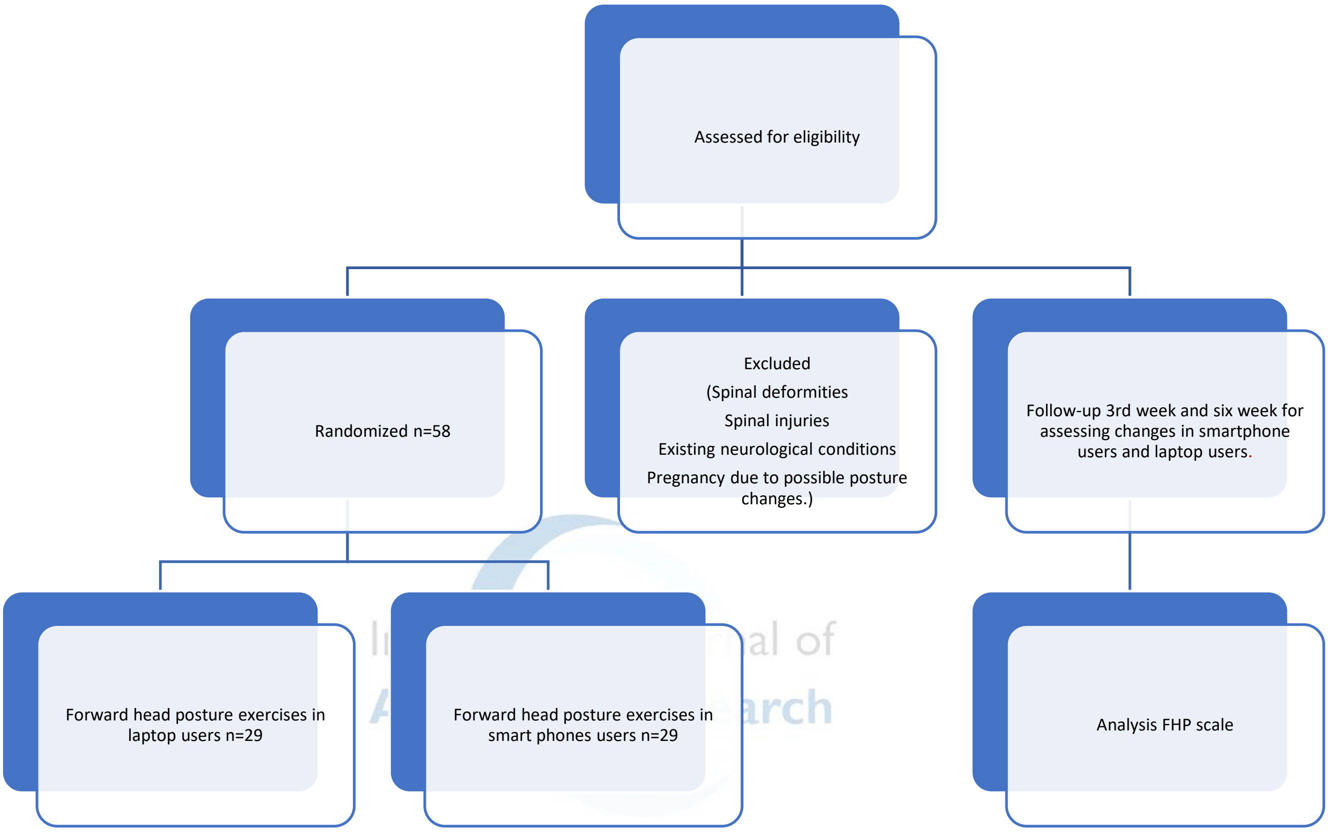
CONSORT Diagram:



RESULTS:

Age-wise Distribution of Participants (n = 58)

Table 1 presents the age-wise distribution of the 58 study participants divided equally between Group A and Group B. The majority of participants in both groups belonged to the 21–23 years age category, comprising 41.4% of Group A and 44.8% of Group B, with an overall representation of 43.1%. This was followed by the 18–20 years age group, which accounted for 37.9% of participants in Group A and 34.5% in Group B (overall 36.2%). The smallest proportion of participants by age in this sample belonged to the age group of 24-25 years, each group contributing 20.7%. Overall, the distribution of subjects by age is very similar across groups, boding well for the balance in the representation of participants across age categories and, by extension, sample homogeneity for subsequent comparisons.

Table 4.1. 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)

Gender-wise Distribution of Participants (n = 58)

Table 4.2 presents the gender distribution of the subjects in the two study groups out of the 58 participants. Group A consisted of 15 males, 51.7%, and 14 females, 48.3%, while Group B comprised 16 males, 55.2%, and 13 females, 44.8%. Overall, males made up a slightly higher share in the study sample, 53.4%, compared to their female counterparts, 46.6%. The gender distribution was comparable between the two groups, indicating a balanced representation of male and female participants and hence assuring that gender-related bias was minimal between the intervention groups.

Table 4.2. 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)

Baseline Demographic and Device-Use Characteristics of Participants

Fig 3 presents a summary of the baseline demographic and device-use characteristics for the participants in both intervention groups. The average age was roughly the same for Group A (21.3 ± 2.1 years) and Group B (21.6 ± 2.0 years), with no statistically significant difference between them. The genders were also distributed similarly, with almost equal numbers of male and female participants in both groups. Smartphones and laptops users had an almost equal distribution between the groups. Their average daily screen time was also similar, with Group A having 4.6 ± 1.1 and Group B having 4.7 ± 1.2. In conclusion, no significant differences were observed between the two groups for any of the baseline demographic or device-use variables ($p > 0.05$), which shows that successful randomization was achieved and groups were comparable at the baseline before any interventions.

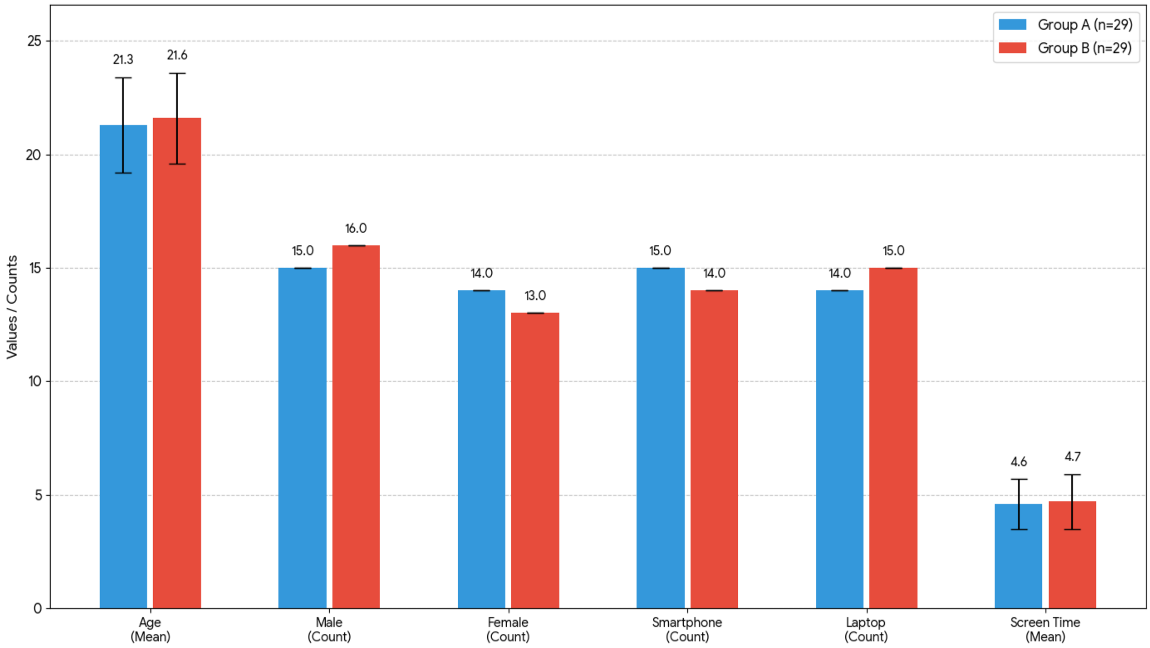


Figure 3. Baseline Demographic and Device-Use Characteristics of Participants

Primary Outcome: Craniovertebral Angle (CVA)

Fig 4 presents the changes in the craniovertebral angle, as measured by CVA, between Group A and Group B over the three assessment time points. The mean CVA scores for Group A and Group B were similar at baseline (Week 0), with 47.2 ± 2.8° and 47.5 ± 3.0°, respectively; these differences are not statistically significant ($p > 0.05$). Hence, the subjects in both groups entered the study with similar severity of forward head posture. By mid-intervention (Week 3), both groups had demonstrated improvement in the CVA values; however, the increase in Group A (50.8 ± 2.6°) was significantly greater than that observed in Group B (49.3 ± 2.7°) ($p < 0.05$). By postintervention (Week 6), there was still a further improvement for both groups; however, Group A revealed a higher mean CVA score (54.6 ± 2.4°) compared to the mean of Group B (52.1 ± 2.5°), and this difference was highly significant ($p < 0.01$). From these data, it can be seen that while both interventions were effective in improving forward head posture over time, posture correction exercises in Group A ensured significantly greater improvement in the craniovertebral angle compared to the strengthening and stretching exercises in Group B.

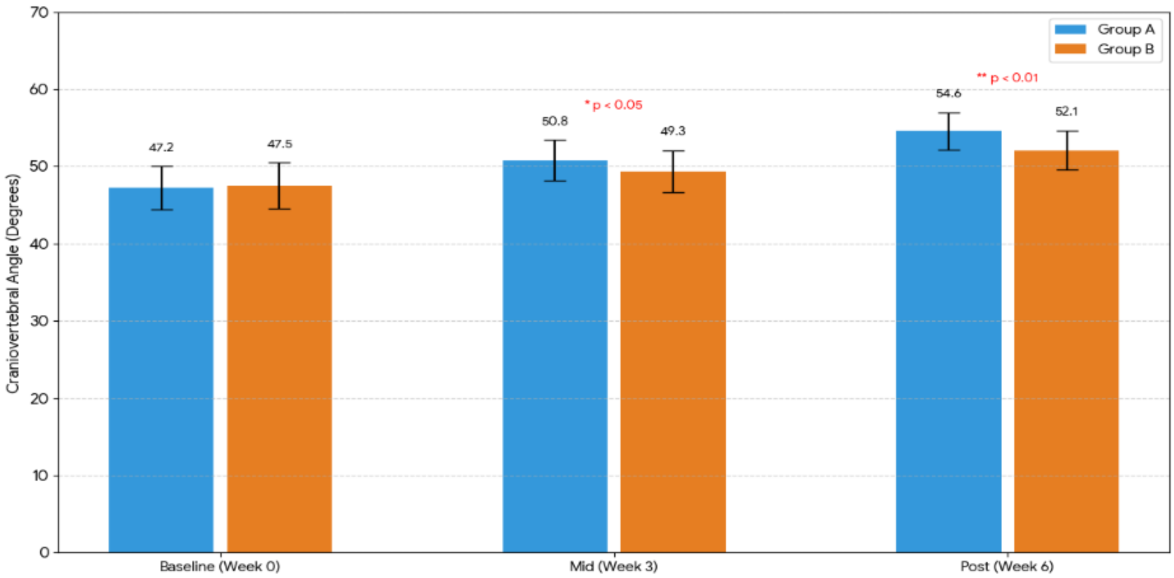


Figure 4. Comparison of Craniovertebral Angle (degrees) Between Groups Across Time

Neck Pain Intensity (NPRS)

The secondary outcome of neck pain intensity, measured by the Numeric Pain Rating Scale, was compared between Group A and Group B at baseline, Week 3, and Week 6. At baseline, both groups had similar pain (Group A: 6.2 ± 1.1, Group B: 6.0 ± 1.2; $p > 0.05$), hence they were comparable before the intervention. By Week 3, neck pain decreased in both groups, but with a greater reduction in Group A (3.8 ± 1.0) than in Group B (4.4 ± 1.1), with statistically significant difference ($p < 0.05$). This further improved at Week 6, where Group A had significantly lower pain intensity (2.1 ± 0.9) compared to Group B (2.9 ± 1.0), and this constituted a highly significant difference ($p < 0.01$). Generally, neck pain decreased over time for both interventions; however, Group A had faster and higher pain relief compared to Group B.

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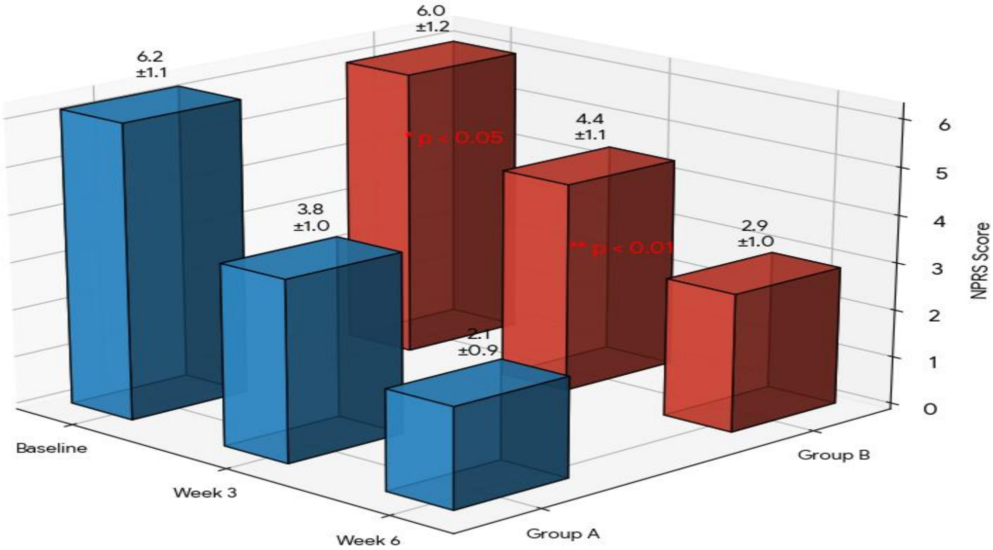

Figure 5. Comparison of Neck Pain Intensity (NPRS) Between Groups

Neck Disability Index (NDI)
Fig 6 Comparison of the secondary outcome, neck disability as measured by the NDI, between Group A and Group B at baseline and post-intervention (Week 6) Both groups had similar disability at baseline (Group A: 24.6 ± 4.8; Group B: 25.1 ± 5.0; $p > 0.05$). Therefore, there was no significant difference between the two groups before the intervention. By Week 6, both groups had reduced their NDI scores, indicating an improvement in neck function. However, the improvement was significantly greater in Group A (11.2 ± 3.9) compared with Group B (14.6 ± 4.2), and this difference was highly significant ($p < 0.01$). This suggests that although both interventions resulted in a reduction in neck disability, Group A resulted in greater improvement in functional outcome.

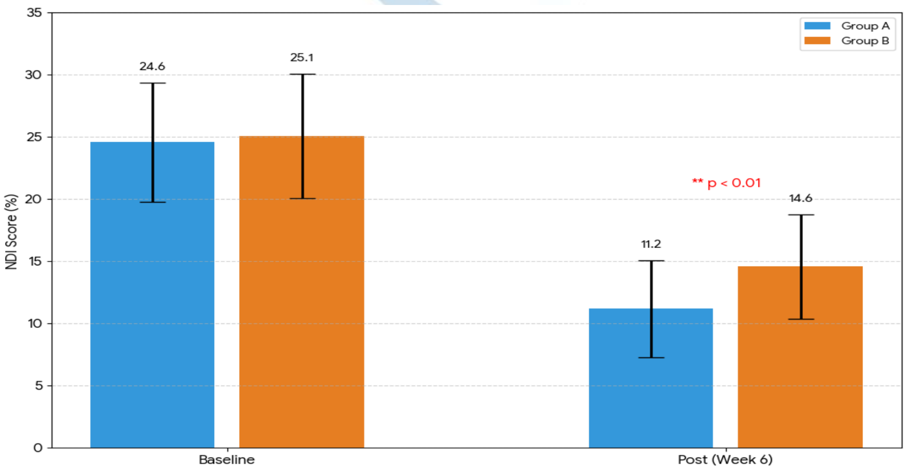

Figure 6. Comparison of Neck Disability Index (NDI) Scores Between Groups

Deep Neck Flexor Endurance (DNFET)
This is the third secondary outcome, deep neck flexor endurance, as measured by the DNFET and compared between Group A and Group B at baseline and post-intervention (Week 6). At baseline, endurance for both groups was similar: Group A, 18.4 ± 5.6 seconds; Group B, 19.1 ± 5.3 seconds; $p > 0.05$, which reflects similar muscle performance before intervention. After six weeks, endurance improved for both groups; however, Group A showed a significantly higher increase, 34.8 ± 6.2 seconds, compared with Group B, 29.6 ± 5.9 seconds, and this difference was highly significant, $p < 0.01$. These results

indicate that both interventions improved deep neck flexor endurance, but the protocol applied to Group A was more effective in enhancing neck muscle performance.

Table 4.7. 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

Discussion: The current randomized controlled trial aimed to compare the effectiveness of two different exercise-based rehabilitation approaches: posture correction exercises with an emphasis on motor control Group A and strengthening and stretching exercises for muscle imbalance Group B, in improving FHP among users of smartphones and laptops. The main outcome measure was the craniovertebral angle, whereas secondary measures included the intensity of neck pain as measured by the NPRS, neck disability as determined by the Neck Disability Index, and the deep neck flexor endurance test. Results show that while both interventions were effective, posture correction exercises resulted in significantly better improvements in all outcomes.The most striking result of this study pertained to the significantly greater CVA improvement in Group A compared with Group B at the mid-intervention and post-intervention assessments. At baseline, both groups exhibited similar CVA values of about 47° degree, reflecting moderate to severe forward head posture. Following six weeks, CVA improved to 54.6° for Group A and 52.1° for Group B, with the between-group difference achieving high statistical significance. These findings are in strong agreement with previous RCTs and systematic reviews that motor control-based posture correction exercises are especially effective in correcting FHP. Harman et al. showed that cervical retraction and postural awareness training resulted in significant increases in the CVA along with improvement in head alignment compared with general strengthening exercise alone (49). Similarly, Falla et al. reported that exercises targeted at neuromuscular control of the deep cervical flexors were associated with superior postural correction compared to nonspecific strengthening programs (50).

The more significant CVA improvement in Group A could thus be explained by the task-oriented retraining of postural alignment. Exercises like chin tucks, wall posture alignment, and cervical retraction using resistance bands directly address faulty head positioning and improve proprioceptive input, which is crucial for maintaining posture correction. In contrast, although Group B addressed muscle tightness and weakness, it may not have effectively retrained the habituated head-neck alignment during functional activities. Similar results were found in a study by Kang et al., who identified significantly higher CVA improvements after posture correction exercises than with stretching-strengthening protocols among users of smartphones. A recent meta-analysis by Lee and Han also reported that exercise programs incorporating postural re-education generate larger and more long-lasting gains in CVA than muscle based programs alone.Both intervention groups significantly reduced neck pain intensity during the six-week period. Yet, Group A had a faster and greater reduction in pain. At Week 6, the NPRS scores decreased from 6.2 to 2.1 in Group A, while in Group B, scores went down from 6.0 to 2.9.This finding is corroborated by the well-established relationship between forward head posture and mechanical neck pain. Improved alignment of the head reduces constant activity of the cervical extensor muscles and abnormal compressive forces on cervical structures (54). Previous studies have mentioned that correcting the posture decreases nociceptive input by restoring the optimal load distribution across cervical joints (55). Ylinen et al. reported that exercises that emphasized cervical posture and control were more effective in reducing pain than strengthening exercises alone (56). Similarly, Lau et al. found that the significant reduction in neck pain among smartphone users was caused by chin-tuck–based interventions within six weeks of intervention (57). Improvement in sensorimotor control and the consequent overall decrease in muscle overactivity, especially in superficial cervical extensors and upper trapezius muscles often over-recruited in individuals with FHP, may also be responsible for the superior pain reduction in Group A (58).The present study showed that both groups reported a significant reduction in neck-related disability, but the improvement was significantly greater in Group A. NDI scores improved by more than 50% in Group A, compared to an approximate improvement of 42% in Group B. These findings are consistent with earlier RCTs reporting that improvements in postural alignment are closely linked to enhanced functional capacity 59. Falla and Jull demonstrated that interventions improving deep cervical flexor function and posture significantly reduce disability scores in patients with chronic neck pain 60. A systematic review by Gross et al. further emphasized that exercise programs focusing on postural control result in clinically significant reductions in NDI, especially when combined with education and alignment training (61). The greater functional gain in Group A probably reflects the additive benefits from improved posture, pain reduction, and enhanced neuromuscular coordination.Both interventions significantly enhanced deep neck flexor endurance; however, Group A had significantly better improvements: 34.8 seconds versus 29.6 seconds at post-intervention. This lends support to the view that motor control–based exercises have a superior effect on activating and sustaining deep cervical flexor function. Previous electromyographic studies have demonstrated that chin-tuck and cervical retraction exercises selectively activate the longus colli and longus capitis muscles 62. Jull et al. also reported that deep neck flexor endurance improved more following motor-control retraining than with strengthening alone 63.

Improvement in endurance is clinically meaningful, considering that reduced deep neck flexor endurance has been strongly associated with FHP, neck pain, and functional disability (64). Enhanced endurance likely contributed to improved postural maintenance during prolonged device use in Group A participants. While both smartphone and laptop users benefited from the interventions, the overall findings of the study suggest that posture correction exercises particularly benefit smartphone users, who typically adopt greater cervical flexion angles during device use. Past kinematic studies have also demonstrated that using smartphones imposes higher cervical loads compared to laptops due to the prolonged state of downward gaze (65).Kim et al. showed that CVA improvements following corrective exercises were superior in smartphone users than in laptop users, thus confirming the device-specificity of alignment-related interventions 66. Current findings underscore the importance of device-specific rehabilitation strategies, especially in subjects with high dependence on smartphones. Clinically, the results support the superiority of posture correction exercises based on motor control theory over those based on traditional strengthening-stretching approaches. Correction of muscle imbalance remains important; however, restoration of postural awareness, proprioception, and neuromuscular coordination seems to be the key mechanism for sustained improvement.These findings empirically support the motor control theory of postural rehabilitation, which consequently places emphasis on retraining movement patterns rather than isolated muscle strength. This has significant implications for physiotherapy practice, curriculum design, and clinical guidelines that address FHP among digital device users.

CONCLUSION: This randomized controlled trial compared the effectiveness of posture correction exercises (PCE) versus general strengthening-stretching exercises (SSE) for managing forward head posture (FHP) in young adult smartphone and laptop users. Following a six-week program, both groups showed improvements in craniovertebral angle, neck pain, disability, and deep neck flexor endurance. However, the PCE group—focusing on motor control, postural re-education, and neuromuscular coordination—demonstrated significantly greater gains in all outcomes. This underscores that FHP is a behavioral and motor control dysfunction, necessitating interventions that target faulty postural habits rather than strength and flexibility alone.

The findings support implementing early, posture-focused rehabilitation to prevent chronic pain and cervical disorders. They provide strong evidence for the clinical superiority of PCE in device-specific physiotherapy programs.

Limitations: The short intervention period and lack of long-term follow-up prevent conclusions about sustainability. Generalizability is limited by a small, homogeneous sample of university students and potential response bias from self-reported measures.

Future Research should investigate long-term outcomes and include more diverse populations

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