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Impact of a Neck Stability Exercise Program on Forward Head Posture and Thoracic Mobility in Young Adults: A Pre-Post Intervention Study

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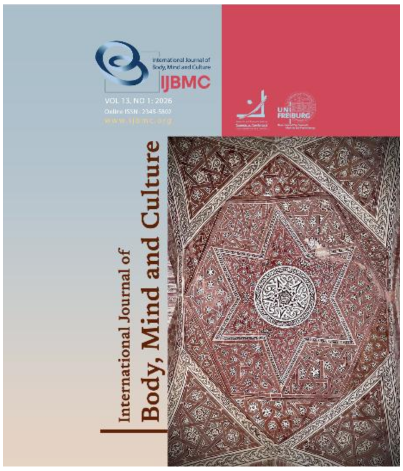

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ABSTRACT

Objective: This study aimed to evaluate the effectiveness of a 4-week neck stability exercise program in improving FHP and thoracic mobility among university students with high digital device usage.

Methods and Materials: A pre-post observational intervention study was conducted with 51 university students aged 19–26 years (mean age = 21.5 ± 2.1 years; 68.5% female). Craniovertebral angle (CVA) was assessed using Surgimap software to evaluate cervical alignment, while thoracic mobility was measured through upper and lower chest expansion. Participants completed a structured neck stability exercise program over four weeks. Pre- and post-intervention measures were compared using paired t-tests with significance set at $p<0.05$.

Findings: Post-intervention analysis revealed a statistically significant enhancement in cervical posture, as evidenced by a mean CVA increase of 0.94° ($t = 28.28$, $p < 0.001$, 95% CI: -1.00 to -0.88). Upper chest expansion also showed significant improvement (mean increase = 0.68 cm, $t = 14.81$, $p<0.001$, 95% CI: -0.78 to -0.58), reflecting better thoracic mobility. However, the change in lower chest expansion was not statistically significant (mean increase = 0.07 cm, $t = 1.32$, $p = 0.192$, 95% CI: -0.04 to 0.19).

Conclusion: The neck stability exercise program was effective in improving forward head posture and upper thoracic mobility among frequent digital device users. These findings highlight the potential of targeted postural interventions in mitigating the musculoskeletal impact of prolonged device use in young adults.

Keywords: Exercise, Mobile Device, Mobility Limitations, Musculoskeletal Pains, Posture.

Introduction

Posture refers to the alignment and balance of the musculoskeletal system that enables the body to maintain positions and perform movements efficiently, while minimizing stress on muscles, joints, and supporting structures. Ideal posture promotes both static and dynamic stability; however, modern sedentary lifestyles—especially increased use of digital devices—have led to common postural deviations. One of the most prevalent is forward head posture (FHP), particularly among individuals who spend prolonged periods on smartphones, tablets, or computers (Ramalingam & Subramaniam, 2019).

FHP is marked by the anterior positioning of the head relative to the spine, often accompanied by rounded shoulders and an exaggerated thoracic kyphotic curve. It is closely associated with upper crossed syndrome (UCS), a pattern of muscular imbalances involving tightness in the pectoralis major and upper trapezius, along with weakness in the deep neck flexors and scapular stabilizers (Sepehri et al., 2024). This altered alignment increases compressive forces on cervical joints and soft tissues, contributing to discomfort and dysfunction.

Beyond musculoskeletal implications, FHP can negatively affect thoracic mobility and respiratory mechanics. Limited rib cage expansion and reduced diaphragmatic excursion have been reported, potentially leading to compromised breathing efficiency and lower lung volumes (Annarumma et al., 2023; Koseki et al., 2019). As the head shifts forward, compensatory muscle activation and postural strain may further restrict thoracic movement and impair respiratory patterns (Solakoğlu et al., 2020).

Although postural concerns are recognized in pediatric and geriatric populations, young adults—despite extensive screen exposure—remain understudied (Hasiholan & Susilowati, 2022). Emerging evidence indicates that digital device usage exceeding six hours per day correlates with increased musculoskeletal complaints such as neck stiffness, shoulder tightness, and breathing difficulties (Bomen & Kulkarni, 2022; Jung et al., 2016). For instance, a study in India found that 70% of physiotherapy students experienced symptoms linked to prolonged smartphone use (Ashok et al., 2020).

Despite growing awareness, the connection between cervical posture and respiratory function due to reduced thoracic mobility remains inconclusive, with some studies finding no significant associations (Ashok et al., 2020). These inconsistencies underscore the need for further research—particularly in university populations—to explore the impact of postural correction strategies and their potential to enhance mobility of thorax.

The aim of this single-group pre-post observational intervention study is to assess the effectiveness of a neck stability exercise program in reducing forward head posture and improving thoracic mobility among young adults with high levels of digital device usage. We hypothesize that a four-week neck stability exercise regimen will result in a statistically significant improvement in craniovertebral angle (indicative of reduced FHP) and enhanced thoracic mobility in this population.

Methods and Materials

Study Design

This was a single group pre-post observational intervention study conducted to assess the effects of a four-week neck stability exercise program on forward head posture (FHP) and thoracic mobility in young adults.

Participants

A total of 54 participants (aged 18–26 years) were recruited between March 14 and May 14, 2024, from various faculties of a private universities in Klang Valley Recruitment was carried out via university-wide emails and social media announcements. On the basis of an expected effect size of 0.565, a minimum sample size of 42 participants was determined to achieve the desired statistical power. In order to account for a potential attrition rate of 10%, the final estimated sample size was adjusted to take into account 54 participants. The sample size for this study was calculated using G*Power version 3.1.9.7.

The inclusion criteria for this study were as follows: participants were required to use digital devices for more than 4 hours per day, demonstrate the presence of forward head posture (as indicated by a craniovertebral angle (CVA) of less than 50°), and have no history of cervical surgery or recent physical therapy interventions. Participants were excluded if they had any neurological disorders, cervical spine pathology, or if they were unable to complete the study or had missing data. These criteria ensured that the sample was homogeneous in terms of digital device use and postural condition while minimizing the potential influence of confounding factors such as underlying medical conditions or prior interventions.

Demographic data, including age, gender, height, weight, and reported screen time, were self-reported via Google Forms and verified using hard copies.

Intervention: Neck Stability Exercise Program

The participants completed a 4-week supervised neck stability exercise program, performed 5 days per week for 20 minutes per session. The protocol included: **Week 1–2**: Chin tucks (3 sets x 10 reps), Isometric neck extension and flexion (3 sets x 10 seconds) and scapular retraction with resistance band. **Week 3–4**: Progression to dynamic head nods and prone cervical extensions, Wall angels and Thoracic mobility drills.

Exercises were demonstrated by a licensed physiotherapist (BPT, MPT) and performed under supervision in a university lab setting. Adherence was monitored using a daily exercise log signed by participants and countersigned by the therapist.

Outcome Measures

1. Cervical Angle (Craniovertebral Angle – CVA)

Postural alignment was assessed using digital photographic analysis. Lateral-view images were captured using a Samsung A34 smartphone. To ensure consistency in image capture, participants stood in a relaxed posture, barefoot, with arms at their sides and eyes looking straight ahead. The subjects were informed to stand erect with feet width apart. Clothing was rearranged so that neck (C7 spine) and shoulders are exposed. Images were captured by camera which was mounted on adjustable tripod stand at a distance of 3 m from the subject's shoulder. The tragus of the ear and the spinous process of C7 were marked, and images were analyzed using Surgimap software. The CVA was defined as the angle between a horizontal line through C7 and a line connecting C7 to the tragus. A CVA angle less than 50° indicates the presence of forward head posture. In this study the participants were photographed twice during the baseline and post-intervention. The participants CVA angle was assessed by the trained rater blinded to time point of assessment. The inter- and intra-rater reliability of Surgimap were reported with ICCs ranging from 0.813 to 0.995 (Khan et al., 2023).

2. Chest Expansion (Thoracic Mobility)

The participants' thoracic mobility was measured using a measuring tape placed around the thorax at three levels: axillary level (upper chest), xiphoid level (middle chest) and subcostal level (lower chest).

During this assessment the participants were instructed to inhale maximally and exhale completely. The difference in chest circumference between inhalation and exhalation was recorded. Three measurements were taken at each level and averaged.

While this method is commonly used in clinical and research settings, it is important to note that the tape measure technique is relatively coarse and may lack sensitivity when used in healthy, asymptomatic populations. Subtle changes in thoracic expansion particularly in younger individuals with normal respiratory function may not be accurately detected using this manual method. More precise alternatives, such as respiratory inductance plethysmography, optoelectronic plethysmography, or 3D motion capture systems, could be considered in future research to provide a more detailed and objective evaluation of respiratory mechanics.

Analysis

Statistical analysis was performed using SPSS version 29, following a series of structured steps. First, normality testing was conducted on all continuous variables using the Shapiro-Wilk test to assess the distribution of the data. Descriptive statistics, including means and standard deviations (mean ± SD), were calculated for both demographic data and outcome measures. The comparison of the pre- and post-intervention values of CVA (cervical vertebral angle) and chest expansion were analysed using the paired-sample t-tests. Effect sizes were calculated using Cohen's d to quantify the magnitude of changes observed. A statistical significance level was set at $p < 0.05$ for all tests.

Ethics

Ethical clearance was granted by the Institutional Review Board of University of Cyberjaya, under approval number UOC/CRERC/AL-ER (70/2024). All participants provided written informed consent prior to participation. As the intervention posed minimal risk, it was not registered as a clinical trial.

Findings and Results

Descriptive statistics for participant demographics and outcome variables are presented in Table 1

Table 1

Demographic Characteristics of Participants (N = 51)

Variable	Category	N (%)	Mean (SD)
Gender	Male	16 (31.4%)	-
	Female	35 (68.5%)	-
Age (years)	Range: 19–26	-	21.5 (2.1)
Weight (kg)	-	-	60.22 (10.95)
Height (cm)	-	-	164.36 (7.10)
BMI (kg/m²)	-	-	22.43 (3.60)

The study sample consisted of 51 participants (16 males, 35 females). The mean age was 21.5 years (SD = 2.1), with participants ranging from 19 to 26 years. The mean weight was 60.22 kg (SD = 10.95), mean height was 164.36 cm (SD = 7.10), and the mean Body Mass Index (BMI) was 22.43 (SD = 3.60).

Table 2

Pre- and Post-Intervention Values for Primary Outcomes

Outcome	Pre-Intervention Mean (SD)	Post-Intervention Mean (SD)	Mean Difference	t-value	p-value	95% CI
Craniovertebral Angle (°)	47.02 (3.12)	47.96 (3.07)	+0.94	28.28	<0.001	-1.00 to -0.88
Upper Chest Expansion (cm)	2.41 (0.50)	3.09 (0.47)	+0.68	14.81	<0.001	-0.78 to -0.58
Lower Chest Expansion (cm)	3.77 (0.59)	3.84 (0.54)	+0.07	1.32	0.192	-0.04 to 0.19

The mean craniovertebral angle improved from 47.02° (SD = 3.12) at baseline to 47.96° (SD = 3.07) post-intervention. This 0.94° improvement was statistically significant (t = 28.28, p < 0.001, 95% CI: -1.00 to -0.88), indicating a correction in neck alignment following the neck stability exercises as shown in Table 2.

Upper Chest Expansion:

The upper thoracic expansion increased from 2.41 cm (SD = 0.50) at baseline to 3.09 cm (SD = 0.47) post-intervention, with a mean increase of 0.68 cm. The change was statistically significant (t = 14.81, p < 0.001, 95% CI: -0.78 to -0.58) as shown in Table 2.Lower Chest Expansion:

The lower chest expansion increased slightly from 3.77 cm (SD = 0.59) to 3.84 cm (SD = 0.54), with a mean change of 0.07 cm, which was not statistically significant (t = 1.32, p = 0.192, 95% CI: -0.04 to 0.19) as shown in Table 2. This suggests that the exercise protocol may have had a limited short-term effect on diaphragmatic or lower thoracic mobility; however, this finding should be interpreted with caution due to the small sample size and short intervention duration.

Discussion and Conclusion

This study investigated whether a four-week neck stability exercise program could improve forward head posture (FHP) and chest expansion among young adult digital device users. The results revealed statistically significant improvements in both craniovertebral angle and upper chest expansion following the intervention. These findings suggest that targeted neck exercises may positively influence postural alignment and aspects of thoracic mobility, even over a relatively short time frame.

However, a critical limitation of this study is the absence of a control group, which restricts the ability to attribute observed improvements solely to the intervention. Without a comparison group, the potential influence of external factors—such as natural posture fluctuation, behavioral change due to participation awareness, or placebo effect—cannot be ruled out. This significantly limits the strength of causal inferences.

Supporting our findings, (Senthilkumar et al., 2019) found that ergonomic advice combined with relaxation and isometric exercises for the neck and shoulders was effective in reducing pain. Similarly, the postural improvements observed in our study align with previous research demonstrating that corrective exercise programs targeting cervical and thoracic musculature can reduce FHP and associated biomechanical stress (Harman et al., 2005). Moreover, Dinesh et al., (2025) reported that Motor Control Therapeutic Neck Exercises led to superior outcomes in reducing pain and improving posture, further supporting the potential value of focused neuromuscular training.

Kamalakannan et al., (2020) examined neck posture, self-reported pain, and disability among smartphone users, revealing that 90% of participants experienced neck-related musculoskeletal issues due to non-ergonomic phone use. These findings underscore the relevance of our study population and the urgency of addressing text neck syndrome through preventive strategies.

While our data showed statistically significant improvement in upper chest expansion, the change in lower chest expansion was not significant. This may indicate that the exercise regimen primarily affected upper thoracic mechanics, with limited impact on diaphragmatic or abdominal breathing patterns. Thus, although our hypothesis—that neck stability exercises can address postural and respiratory limitations in frequent digital users—was partially supported, the link between posture and respiratory function should be interpreted with caution. The respiratory assessment relied solely on chest expansion, which does not comprehensively capture pulmonary function or ventilation.

The demographic profile of the sample, with a mean age of 22 years and a predominance of female participants (68.5%), reflects a relevant segment of digital device users. However, no subgroup analysis was conducted to explore potential gender-based differences in outcomes. As a result, speculative statements regarding gender-specific responses to the intervention (e.g., differences in flexibility or adherence) were omitted due to the absence of supporting statistical evidence.

A notable strength of this study lies in its use of objective measurement tools—such as Surgimap software for FHP assessment—enhancing measurement precision. Nevertheless, the study's limitations include not only the lack of a control group, but also the absence of screen-time quantification, potential selection bias, and untracked adherence to the exercise program. Furthermore, the short duration limits insight into the long-term sustainability of improvements.

Future research should employ randomized controlled trial designs with control groups to strengthen causal inference. Studies should also include more diverse participant samples, validated respiratory assessment tools, and follow-up periods to assess the persistence of benefits. Additionally, comparing different exercise protocols may help identify the most effective strategies for mitigating the biomechanical consequences of prolonged digital device use

This study underscores the potential value of incorporating neck stability exercises into preventive and rehabilitative strategies for young adults exhibiting forward head posture (FHP) and reduced upper chest expansion due to prolonged digital device usage. The findings suggest that even short-term, structured interventions can produce measurable improvements in postural alignment and thoracic mobility, particularly in the upper chest region. Objective assessment tools such as Surgimap software proved useful for quantifying cervical posture changes, highlighting the feasibility of integrating digital technologies into clinical postural evaluations. Additionally, chest expansion was assessed using a standard measuring tape, a simple and accessible tool commonly used in clinical practice. While it offers practicality and ease of use, this method may lack the precision of more advanced respiratory assessment tools, which should be considered when interpreting thoracic mobility outcomes. These results have practical implications for physiotherapists, occupational health professionals, and educational institutions, where simple, evidence-informed interventions could be integrated into wellness programs targeting students and desk-based workers. However, the study design without a control group limits causal interpretations. The use of convenience sampling, reliance on self-reported data, and short intervention duration also constrain the generalizability and long-term applicability of the results. Additionally, the absence of screen-time quantification despite it being central to the "digital user" concept represents a missed opportunity for a more nuanced understanding of behavior-posture relationships. Future studies should employ randomized controlled trials with larger, more diverse populations, monitor exercise adherence, and include long-term follow-up to assess the sustainability of improvements.

Furthermore, incorporating validated measures of pulmonary function (e.g., spirometry) could clarify the extent to which posture influences respiratory outcomes. By addressing these gaps, future research can more definitively establish the clinical relevance of postural correction in populations at risk due to digital lifestyles.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Ethical considerations in this study were that participation was entirely optional.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contribute to this study.

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