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Adaptation of Forward Head Posture following Temporomandibular Joint mobility, Diaphragmatic Breathing and Neck Stability Exercise among Digital Screen Users

Multimodal Intervention for Forward Head Posture

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ABSTRACT: **Background**: Forward Head Posture (FHP) is associated with altered cervical alignment, temporomandibular joint (TMJ) dysfunction, impaired respiratory mechanics, and neck-related disability. Multimodal rehabilitation strategies may offer superior outcomes compared to isolated interventions.

Objective: This study aimed to evaluate the effects of combined TMJ mobility, deep breathing, and neck stability exercises on postural alignment and functional outcomes in individuals with and without neck pain.

Methods: A pre-post quasi-experimental study recruited fifty participants were non-randomly allocated into four groups: neck stability, diaphragmatic breathing, TMJ mobility, and combined intervention. All participants completed baseline and post-intervention assessments following a four-week exercise program. Outcomes included CVA, Neck Disability Index (NDI), maximal TMJ opening, chest expansion, and pain intensity. Data normality was assessed using Shapiro–Wilk tests and Q–Q plots. Within-group changes were analyzed using paired t-tests, and between-group effects were examined using two-way repeated measures ANOVA, with post-hoc comparisons where applicable.

Results: The combined intervention group demonstrated significant improvements in CVA (+5.1° ±3.9), TMJ opening (+1.6 ±1.2 mm), and NDI reduction (−18.6 ±8.0), along with increased upper (0.21 ±0.19 in) and lower chest expansion (0.16 ±0.17 in). Neck stability training showed the greatest reduction in disability (−25.0 ±7.5), breathing exercises produced largest improvement in lower chest expansion (0.28 ±0.30 in). The combined protocol produced the most consistent improvements across outcomes ($p < 0.05$).

Conclusion: A multimodal exercise program integrating TMJ mobility, breathing, and neck stability exercises is more effective than single-intervention approaches in improving posture, reducing disability, enhancing respiratory function, and optimizing TMJ mobility.

INTRODUCTION

Forward head posture (FHP) is a prevalent postural deviation characterized by anterior positioning of the head relative to the trunk. In ideal posture, when viewed laterally, the external auditory meatus aligns vertically with the shoulder and hip, indicating a neutral head position. FHP, by contrast, involves the external auditory meatus projecting forward of this vertical line. This malalignment is one of the most common poor postures observed, especially in individuals with neck disorders. The condition has garnered increased attention in recent years due to its rising incidence among people who spend extended periods using digital devices such as computers and smartphones. This chapter provides background on FHP and its association with digital device use, outlines the musculoskeletal and physiological impacts of FHP, discusses the positive and negative aspects of digital device usage, and highlights the research gap and need for the present study.

Modern lifestyles have led to a surge in prolonged sitting and screen time, contributing to widespread postural issues. The tendency to remain seated and use personal computers or smartphones for hours has increased significantly over the past two decades. Studies have documented that this behaviour can alter the alignment of the spine and shoulders, often resulting in a rounded upper back and forward positioning of the head. Repetitive or sustained neck flexion while viewing screens is a known risk factor for developing FHP. Another study demonstrated that smartphone users commonly adopt flexed head positions, which can lead to musculoskeletal disorders over time (1). Further showed that when individuals assume an arms-forward posture (such as holding a phone), the head flexion angle increases significantly compared to an upright posture with arms resting, indicating that device usage posture directly exacerbates forward head positioning (2).

Beyond musculoskeletal effects, FHP has notable physiological impacts, particularly on respiratory function and temporomandibular joint (TMJ) mechanics. Posture and breathing are intimately linked. In a normal posture, the diaphragm – the primary muscle of respiration, operates efficiently with balanced support from the intercostal and abdominal muscles. However, FHP and thoracic kyphosis can disrupt this balance (3). Research has shown that FHP is associated with altered thoracic geometry: a study by (4) found that FHP in adults causes an expansion of the upper ribcage and a contraction of the lower ribcage. These morphological changes effectively reduce the space for diaphragmatic descent and lung expansion, leading to diminished respiratory function. Adopting a forward head posture can acutely impair diaphragmatic muscle strength and mobility, resulting in immediate negative effects on measures of lung function. In their study, voluntary FHP posturing led to decreased lower thoracic expansion and lower diaphragm excursion, confirming that cervico-thoracic posture can influence breathing mechanics (5).

MATERIALS AND METHODS

Study Design

The study utilized a quasi-experimental, quantitative research design and was structured as a multi-arm pre-test/post-test intervention trial. As the study did not involve randomization, its reporting was guided by the TREND (Transparent Reporting of Evaluations with Nonrandomized Designs) statement to ensure transparency and methodological rigor in nonrandomized intervention research

Study Setting

The study was conducted at a private University, located in the Klang Valley, Malaysia, with the primary site being the Physiotherapy Department facilities. Recruitment of participants was supported by nearby educational institutions, targeting individuals who are regular digital device users. Data collection and assessments were carried out in a designated clinical assessment room to ensure standardized measurement procedures, while supervised exercise sessions were conducted in the gymnasium area within the university facilities.

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Participants

A total of 45 participants aged 18–40 years, of either sex, with a craniovertebral angle (CVA) <50° were recruited. Participants with or without chronic neck pain were eligible, provided they had good cognitive status and no upper-limb neurological deficits. Participants were excluded if they had received physiotherapy for neck pain within the previous 6 months, regularly participated in sports or vigorous physical exercise, had a history of significant cervical spine injury, inflammatory arthritis, cardiac conditions, diabetes mellitus, vertebrobasilar insufficiency, TMJ injury or recent TMJ surgery, or severe TMJ disorders requiring medical management. Sample size estimation was performed using G*Power, assuming a medium effect size (f = 0.5), $\alpha = 0.05$, and 80% statistical power. The minimum required sample was 36 participants, which was increased to 45 to account for an anticipated 20% attrition rate. Participants underwent baseline assessment, followed by a 4-week intervention and post-intervention assessment, and were allocated to one of four parallel groups: diaphragmatic breathing, TMJ mobility, neck stability, or combined neck stability, diaphragmatic breathing, and TMJ mobility exercises.

Intervention Procedures

Participants were allocated into four parallel intervention groups: Group 1 received diaphragmatic breathing exercises, Group 2 received TMJ mobility exercises, Group 3 received neck stability exercises, and Group 4 received a combined intervention consisting of neck stability, diaphragmatic breathing, and TMJ mobility exercises.

Intervention

Neck Stability Exercise Protocol

Participants performed craniocervical flexion exercises using a pressure biofeedback unit in the supine position. The pressure cuff was initially inflated to 20 mmHg, and participants performed gentle craniocervical nodding to progressively achieve target pressures of 22–30 mmHg while minimizing superficial neck muscle activation. Each session consisted of 3 sets of 10 repetitions, with each contraction held for 10 seconds. The target pressure was progressed by 2 mmHg when participants demonstrated correct technique without compensatory muscle activation. Training was conducted twice weekly for 4 weeks, comprising eight supervised sessions of approximately 20–30 minutes each.

Diaphragmatic Breathing Exercise Protocol

Participants performed diaphragmatic breathing in the supine position with knees flexed, using one hand on the chest and the other on the abdomen to monitor breathing pattern. They were instructed to inhale slowly through the nose with predominant abdominal expansion and minimal chest movement, followed by a slow exhalation through pursed lips. Each session lasted 5 minutes and was performed 3–4 times daily for 4 weeks. Participants received initial physiotherapist instruction, weekly technique review, and a breathing log to monitor adherence.

TMJ Mobility Exercise Protocol

Participants performed self-mobilization exercises to improve temporomandibular joint (TMJ) mobility and reduce masticatory muscle tension. The protocol included gentle passive TMJ stretching, medial glide self-mobilization, and controlled mouth opening and closing with mirror feedback to minimize mandibular deviation. Participants performed 5 repetitions of each exercise, with approximately 5-second holds for the stretching and mobilization exercises. The routine required approximately 5–10 minutes per session and was performed twice daily for 4 weeks. Exercises were initially demonstrated and supervised by a physiotherapist, with participants instructed to perform the movements gently without provoking pain or excessive clicking.

Combined Exercise Protocol

Participants in the combined group received all three interventions: supervised neck stability exercises twice weekly, diaphragmatic breathing exercises for 5 minutes, 3–4 times daily, and TMJ mobility exercises for 5–10 minutes twice daily, for 4 weeks. During supervised sessions, the physiotherapist monitored and corrected the technique of all exercise components. Participants were provided with a written exercise log to record daily adherence. The combined intervention was designed to integrate the three exercise components without substantially increasing the overall training burden.

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Outcome Measures

The outcome measures included the craniovertebral angle (CVA) to assess forward head posture using surgimap software, the Neck Disability Index (NDI) to evaluate neck pain-related disability, temporomandibular joint (TMJ) range of motion using vernier caliper to assess jaw mobility, chest expansion using measuring tape to assess respiratory function, and the Numeric Pain Rating Scale (NPRS) to evaluate pain intensity.

Statistical Analysis

Data normality was assessed using the Shapiro–Wilk test and Q–Q plots. The distribution of the outcome measures and model residuals was considered acceptable for parametric analysis. Levene's test was used to assess the homogeneity of variances across the four intervention groups, with $p > 0.05$ indicating that the assumption of equal variances was satisfied. Paired-samples t-tests were used to assess within-group differences between pre- and post-intervention measurements. A two-way mixed-design repeated-measures ANOVA was performed to examine the effects of time (pre- and post-intervention) and group (four intervention groups), including the time × group interaction. Tukey's Honestly Significant Difference (HSD) post-hoc test was performed for pairwise comparisons. Statistical significance was set at $p < 0.05$.

RESULTS

Baseline Associations Between Craniovertebral Angle, Neck Disability, and Other Variables

At baseline, a significant positive correlation was observed between craniovertebral angle (CVA) and lower chest expansion ($r = 0.348$, $p = 0.019$), indicating a weak-to-moderate association between these variables. No significant correlations were observed between CVA and upper chest expansion, TMJ opening, or Neck Disability Index (NDI) scores. Similarly, NDI scores were not significantly correlated with lower or upper chest expansion or TMJ opening. Independent-samples t-tests showed no significant differences between male and female participants in CVA ($t = 0.54$, $p = 0.592$) or NDI scores ($t = -0.85$, $p = 0.400$) (Table 1).

Variable 1	**Variable 2**	**Pearson r**	**p-value**
CV angle (degrees)	Lower chest expansion (in)	+0.348	0.019 *
CV angle (degrees)	Upper chest expansion (in)	+0.066	0.668
CV angle (degrees)	TMJ opening (mm)	–0.150	0.326
CV angle (degrees)	NDI score	–0.179	0.240
NDI score	Lower chest expansion (in)	+0.148	0.333
NDI score	Upper chest expansion (in)	–0.029	0.851
NDI score	TMJ opening (mm)	–0.204	0.168
Gender (Male vs Fem)	CV angle (degrees)	t = 0.54	0.592
Gender (Male vs Fem)	NDI score	t = –0.85	0.400

Pre- and Post-Intervention Outcomes in the Diaphragmatic Breathing Exercise Group

Following 4 weeks of diaphragmatic breathing exercises, significant improvements were observed in CVA, lower chest expansion, upper chest expansion, and NDI scores compared with baseline ($p < 0.05$). CVA increased from 46.0° ± 2.1° to 48.6° ± 2.3° ($p < 0.001$), while lower and upper chest expansion increased by 0.28 and 0.21 inches, respectively. NDI scores decreased from 27.2 ± 7.4 to 2.6 ± 2.9 ($p < 0.001$). However, the increase in TMJ opening from 41.8 ± 4.6 mm to 42.4 ± 4.5 mm was not statistically significant ($p = 0.077$).

Outcome Measure	Baseline (Mean ± SD)	After 4 Weeks (Mean ± SD)	Actual Change	Percent Change	p-value (paired t-test)
Craniovertebral Angle (°)	46.0° ± 2.1°	48.6° ± 2.3°	+2.6°	+5.5%	< 0.001
Lower Chest Expansion (in)	2.66 ± 0.28	2.94 ± 0.30	+0.28	+10.9%	0.004
Upper Chest Expansion (in)	2.71 ± 0.27	2.92 ± 0.25	+0.21	+7.8%	0.028
Neck Disability Index	27.2 ± 7.4	2.6 ± 2.9	–24.6	–90.6%	< 0.001
TMJ Opening	41.8 ± 4.6	42.4 ± 4.5	+0.6 ± 0.9	1.44%	0.077

Pre- and Post-Intervention Outcomes in the TMJ Mobility Exercise Group

After 4 weeks of TMJ mobility exercises, significant improvements were observed in all measured outcomes. CVA increased from 44.4° ± 2.8° to 45.3° ± 2.7° (p = 0.010), while TMJ opening increased from 43.9 ± 1.5 mm to 45.0 ± 1.4 mm (p = 0.003). Lower and upper chest expansion also demonstrated significant increases (p = 0.004 and p = 0.010, respectively). NDI scores significantly decreased from 27.3 ± 6.6 to 5.9 ± 2.9 (p < 0.001), indicating a substantial reduction in neck-related disability.

Outcome Measure	Baseline (Mean ± SD)	After 4 Weeks (Mean ± SD)	Actual Change	Percent Change	Significance
CV Angle (degrees)	44.4° ± 2.8°	45.3° ± 2.7°	+0.9°	+1.8%	p = 0.010
TMJ Opening (mm)	43.9 ± 1.5	45.0 ± 1.4	+1.1 mm	+2.5%	p = 0.003
Lower Chest Expansion (in)	2.61 ± 0.26	2.78 ± 0.30	+0.17 in	+6.4%	p = 0.004
Upper Chest Expansion (in)	2.68 ± 0.25	2.89 ± 0.27	+0.21 in	+7.9%	p = 0.010
Neck Disability Index (NDI)	27.3 ± 6.6	5.9 ± 2.9	–21.4	–78.5%	p < 0.001

Pre- and Post-Intervention Outcomes in the Neck Stability Exercise Group

Following 4 weeks of neck stability exercises, significant improvements were observed across all outcome measures. CVA increased from 44.5° ± 3.2° to 49.6° ± 3.4° (p = 0.005), representing an improvement of 5.1°. NDI scores decreased from 29.4 ± 7.5 to 4.4 ± 2.7 (p < 0.001). Significant increases were also observed in lower and upper chest expansion and TMJ opening, with changes of 0.21 inches, 0.12 inches, and 1.7 mm, respectively.

Outcome Measure	Baseline (Mean ± SD)	After 4 Weeks (Mean ± SD)	Actual Change	Percent Change	Significance
Craniovertebral Angle (°)	44.5° ± 3.2°	49.6° ± 3.4°	+5.1°	+11.4%	$p = 0.005$
Neck Disability Index (NDI)	29.4 ± 7.5	4.4 ± 2.7	–25.0	–84.9%	$p < 0.001$
Lower Chest Expansion (in)	2.71 ± 0.33	2.92 ± 0.30	+0.21	+7.8%	$p = 0.028$
Upper Chest Expansion (in)	2.68 ± 0.27	2.80 ± 0.26	+0.12	+4.6%	$p = 0.010$
TMJ Opening (mm)	45.6 ± 1.9	47.2 ± 1.5	+1.7 mm	+3.7%	$p < 0.001$

Comparison of Changes in Outcome Measures Across the Four Intervention Groups

The combined and single-intervention groups demonstrated improvements across the assessed outcome measures following the 4-week intervention. The greatest improvement in CVA was observed in the combined and neck stability groups, both showing a mean increase of 5.1°. The largest reduction in NDI score was observed in the neck stability group (−25.0 points), followed by the diaphragmatic breathing group (−24.6 points) and TMJ mobility group (−21.4 points). The greatest improvement in TMJ opening was observed in the neck stability group (+1.7 mm), followed by the combined group (+1.6 mm). Lower chest expansion showed the greatest increase in the diaphragmatic breathing group (+0.28 inches), whereas upper chest expansion improved by approximately 0.21 inches in the combined, diaphragmatic breathing, and TMJ mobility groups.

Measure	Combined (All)	Neck Only	Breathing Only	TMJ Only	Significant Tukey HSD comparisons
CV Angle Change (°)	+5.1° (±3.9°)	+5.1° (±4.0°)	+2.5° (±0.7°)	+0.8° (±0.7°)	Combined vs TMJ: $p < 0.01$; Combined vs Neck: $p \approx 1.00$; Combined vs Breathing: $p \approx 0.21$
NDI Change (points)	–18.6 (±8.0)	–25.0 (±7.5)	–24.6 (±7.4)	–21.4 (±6.6)	No significant pairwise differences ($p > 0.05$)
TMJ Opening Change (mm)	+1.6 (±1.2)	+1.7 (±1.5)	+0.6 (±0.9)	+1.1 (±1.3)	Combined vs Breathing: significant; Combined vs TMJ: $p \approx 0.70$
Lower Chest Expansion (in)	+0.16 (±0.17)	+0.21 (±0.30)	+0.28 (±0.30)	+0.17 (±0.26)	No significant difference between Combined and Breathing ($p \approx 0.21$)
Upper Chest Expansion (in)	+0.21 (±0.19)	+0.12 (±0.26)	+0.21 (±0.25)	+0.21 (±0.27)	No major significant pairwise differences reported

DISCUSSION

This research involved young adults using digital devices as the target population and examined the main factors related to forward head posture (FHP), as well as assessing the effectiveness of three intervention strategies: diaphragmatic breathing exercises, temporomandibular joint (TMJ) mobility exercises, and neck stability exercises individually and in combinations.

Recent evidence indicates that breathing mechanics and cervical posture are closely interrelated. Forward head posture has been shown to reduce diaphragmatic efficiency and alter thoracic mechanics, leading to increased reliance on accessory respiratory muscles such as the sternocleidomastoid and scalenes (6). This upper chest–dominant breathing pattern contributes to muscular imbalance in the cervical region (7).

Diaphragmatic breathing exercise in this study led to modest improvements in posture alongside significant reductions in neck disability (NDI) and enhanced respiratory function. These results indicate a clinically relevant dual benefit, reflecting the diaphragm's integrated role in both respiration and postural control. Beyond ventilation, the diaphragm contributes to core stability through intra-abdominal pressure regulation and coordination with trunk and cervical muscles, which may help explain its effects on neck pain and functional outcomes.

The TMJ mobility exercises produced only a minimal change in craniovertebral (CV) angle, suggesting that directly targeting the jaw has limited influence on static head posture. This finding is consistent with recent evidence indicating that, although the temporomandibular joint and cervical spine are functionally interconnected, forward head posture is predominantly driven by cervical and thoracic alignment rather than isolated TMJ mechanics (8).

Systematic evidence further suggests that TMJ and cervical spine dysfunctions share a primarily functional relationship, where changes in one region do not necessarily induce structural postural correction in the other (9).

However, the significant improvement in Neck Disability Index (NDI) observed in the TMJ group indicates an indirect but clinically meaningful relationship between TMJ function and neck comfort. This may be explained by shared neuromuscular control and trigeminocervical interactions, whereby improved TMJ function can reduce cervical muscle tension and pain without producing substantial alterations in global head posture (7).

FHP increases the load on cervical extensor muscles and joints; by retracting the head (increasing CV angle), those structures get relief and the deep flexors provide support, leading to less nociceptive input from overloaded tissues (10).

This supports the study by neck stability training, in particular, yielded both large postural improvements and pain relief. This suggests that even if FHP isn't linearly related to pain at a static point in time, working to correct FHP (especially by activating deep stabilizers) does help alleviate pain over time.

CONCLUSION

This study demonstrates that forward head posture (FHP) is a multidimensional condition influenced by postural, respiratory, cervical, and cranio-mandibular factors. A 4-week diaphragmatic breathing programme improved respiratory function and contributed to improvements in posture and neck-related outcomes, while TMJ mobility exercises primarily improved mandibular function and reduced neck pain and disability. Deep cervical flexor and neck stabilization exercises produced substantial improvements in craniovertebral angle and neck disability, supporting their role in FHP management. The combined intervention addressing TMJ mobility, diaphragmatic breathing, and neck stability produced improvements across multiple clinical domains, suggesting that an integrated approach may provide broader benefits than targeting posture alone. These findings highlight the potential value of incorporating respiratory and temporomandibular assessment and intervention alongside conventional cervical rehabilitation for individuals with FHP. Further research involving larger samples, controlled designs, and longer follow-up is warranted to establish the long-term effectiveness and clinical applicability of these interventions.

Implications for Clinical Practice

The findings support a multidimensional approach to the management of forward head posture (FHP), incorporating deep cervical flexor strengthening, diaphragmatic breathing retraining, and TMJ mobility exercises according to individual clinical presentation. Clinicians should consider assessing breathing patterns and temporomandibular function alongside conventional postural and cervical assessments, as these factors may contribute to symptoms and functional limitations. These simple, low-cost interventions can be incorporated into supervised physiotherapy and home-based programmes to improve posture, reduce neck pain and disability, and enhance respiratory and cranio-mandibular function.

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