Combined Effect of Bruegger's Exercise and Hand Grip Training on Postural Correction and Cervical Endurance in Chronic Smartphone Users

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ABSTRACT

Background: Prolonged smartphone use is associated with forward head posture, reduced cervical muscle endurance, and altered upper-limb function in young adults. Postural correction exercises are commonly prescribed; however, the additional effect of distal strengthening on cervical endurance and postural alignment remains unclear.

Aim: To evaluate the combined effect of Bruegger's exercise and hand-grip training on postural correction and cervical endurance in chronic smartphone users.

Objective: To compare the effectiveness of Brugger's exercise alone and Brugger's exercise combined with hand-grip training on cervical muscle endurance, craniovertebral angle, and hand-grip strength in young adults with chronic smartphone use.

Methods: A single-blinded, parallel-group randomized controlled trial was conducted among 30 participants aged 18–30 years with forward head posture and smartphone use of ≥4 hours/day. Participants were randomly allocated into Group A (Brugger's exercise) and Group B (Brugger's exercise combined with hand-grip training).The intervention was performed five days per week for four weeks. Neck flexor endurance (primary outcome), craniovertebral angle, and hand-grip strength (secondary outcomes) were assessed at baseline and post-intervention. Within-group comparisons were performed using paired t-tests, and between-group comparisons of mean change scores were performed using independent t-tests. Effect size was calculated using Cohen's d.

Results: Both groups showed significant improvement in all outcome measures ($p < 0.05$). However, the combined intervention group demonstrated significantly greater improvement compared to the Brugger's exercise-only group in neck flexor endurance (mean difference = 6.7 seconds; $p < 0.001$), craniovertebral angle (mean difference = 4.4°; $p = 0.002$), and hand-grip strength (mean difference = 4.0 kg; $p = 0.001$). Large effect sizes were observed for neck flexor endurance ($d = 1.2$) and craniovertebral angle ($d = 0.95$), and a moderate-to-large effect size for hand-grip strength ($d = 0.88$). High adherence and no serious adverse events were reported.

Conclusion: Brugger's exercise combined with hand-grip training is more effective than Brügger's exercise alone in improving cervical muscle endurance, postural alignment, and hand-grip strength in young adults with prolonged smartphone use. A multimodal approach targeting both proximal postural muscles and distal strength may be recommended for rehabilitation of smartphone-related postural dysfunction.

Keywords: Forward head posture; Brugger's exercise; hand-grip strength; cervical muscle endurance; smartphone use; randomized controlled trial.

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INTRODUCTION

The widespread use of smartphones, particularly among young adults, has led to prolonged static postures characterized by sustained neck flexion and rounded shoulders, resulting in increased mechanical stress on the cervical spine and surrounding musculature.[1] Using a smartphone has become a necessity in today's environment. People frequently hold incorrect postures for extended periods of time as a result of spending a lot of time on social media,

texting, or surfing. Continuously bending the head forward while looking at a smartphone screen results in a slouched upper back, rounded shoulders, and a forward head posture. Prolonged smartphone use has been associated with muscle fatigue, pain, and reduced functional capacity, and a significant relationship has been reported between cervical posture, muscle endurance, and duration of smartphone use.[2] Over time, these bad posture patterns cause musculoskeletal imbalances and pain, especially in the upper back, shoulders, and neck.[16,21]

For muscles and joints to work well and for the body to be properly aligned, maintaining excellent posture is crucial. A balanced head, neck, shoulders, and spine minimize unnecessary effort on muscles when posture is proper. On the other hand, overusing a smartphone makes the shoulders round and the head slant forward. Every time the head bends forward, the cervical spine bears a greater weight, which continuously strains the ligaments and muscles of the neck. If held for extended periods of time, this position disturbs off the body's natural equilibrium and can cause persistent shoulder and neck pain.[17] Forward head posture is strongly correlated with neck pain and disability due to altered sagittal spinal alignment and increased compressive forces on cervical structures.[3,4]

A number of muscles and joints that support stability and posture made up the cervical and thoracic areas. The pectoralis major, pectoralis minor, upper trapezius, levator scapulae, and sternocleidomastoid muscles are among the anterior muscles that become tightened due to poor posture. In addition, it weakens posterior muscles such as the rhomboids, middle and lower trapezius, and deep cervical flexors. These imbalances put more strain on ligaments and joints and change the cervical spine's natural curvature. This may eventually lead to stiff necks, decreased joint mobility, and muscular exhaustion.[18] The pectoralis minor plays an important role in scapular positioning, and its resting length has been identified as a reliable clinical indicator of rounded shoulder posture and upper-quarter alignment.[6,8] Alterations in pectoralis minor length influence scapular kinematics and contribute to the persistence of faulty cervical posture and mechanical strain.[7]

In order to support the head, the forward head position causes the centre of gravity to shift anteriorly, which increases the effort required by the posterior neck muscles. Both pain and microtrauma result from this overuse. Chest muscles shrink and the trapezius and rhomboids, two upper back muscles, become weak and overstretched, which exacerbates the rounded shoulder posture. Apart from the effects on muscles, bad posture can also hinder blood flow and compress cervical nerves, resulting in symptoms including headaches, upper back pain, shoulder stiffness, neck pain, and even tingling or numbness in the upper limbs.[22]

Cervical and thoracic alignment also affects distal upper-limb function. Variations in head and neck posture influence hand-grip strength, and standardized positioning of the forearm and trunk is essential for accurate grip assessment.[9,11] Hand-strengthening exercises have demonstrated improvements in grip force and functional performance, suggesting that distal muscle strengthening may enhance proximal stability through neuromuscular coupling mechanisms.[12]

To increase the hand and forearm muscles strength and endurance, hand grip exercise will be utilized. Overall stability and functional performance of the upper limbs will be improved. Improved control and synchronization of arm motions will be supported by a stronger hand grip, which will help indirectly enhance posture when doing daily tasks. Frequent hand grip exercises can help lessen the forearm and hand strain brought on by prolonged smartphone use. Additionally, they will increase upper limb muscular activation and blood circulation. This training will be crucial for preserving upper body strength and promoting proper posture because hand grip strength is linked to total muscular function and endurance.[24]

Exercise-based rehabilitation is widely recommended for the management of forward head posture and associated cervical dysfunction. Neck-specific exercise programs have been shown to reduce pain and disability in smartphone users.[13] Corrective exercise programs have been shown to improve craniovertebral angle and cervical muscle endurance in individuals with forward head posture.[5] A recent systematic review and meta-analysis has confirmed the effectiveness of corrective exercises in improving forward head posture.[14] Altered recruitment patterns of the neck and shoulder muscles during sustained sitting postures highlight the importance of restoring muscular balance and postural stability.[15]

Exercises for postural correction will be crucial in helping the spine return to its natural alignment and in strengthening the muscles needed to maintain good posture. By strengthening the weak muscles and loosening the tight ones, these workouts will help the musculoskeletal system regain its equilibrium. Bruegger's exercise will be the main focus among the various posture correction techniques due to its ease of use and efficiency.[21] The relief position, which is

another name for Bruegger's exercise, will assist extend the spine and open up the chest. The postural muscles that maintain spinal alignment will be activated by encouraging upright sitting with the chin slightly tucked in and the shoulders pushed back. Frequent usage of this exercise will enhance breathing, raise awareness of proper posture, and relieve tension brought on by extended sitting or smartphone use.[23]

Although the effectiveness of postural correction exercises has been well established, there is limited evidence investigating the additional benefit of combining postural re-education with distal strengthening strategies such as hand-grip training in chronic smartphone users.

Therefore, the present study was designed to determine the combined effect of Brugger's exercise and hand-grip training on postural correction and cervical endurance, and upper-limb strength in chronic smartphone users.

AIM AND OBJECTIVE

Aim:

To evaluate the combined effect of Bruegger's exercise and hand-grip training on postural correction and cervical endurance in chronic smartphone users.

Objectives:

1. To determine the effect of Bruegger's exercise on postural correction and cervical endurance in chronic smartphone users.
2. To determine the effect of hand-grip training on postural correction and cervical endurance in chronic smartphone users.
3. To determine the combined effect of Bruegger's exercise and hand-grip training on postural correction and cervical endurance in chronic smartphone users.

Material and method

Study Design and Reporting

This study was designed as a single-blinded, parallel-group randomized controlled trial with a 1:1 allocation ratio. The trial was conducted in the Department of Physiotherapy, Karad, Maharashtra, India, over a period of four weeks. The study protocol followed the ethical principles of the Declaration of Helsinki and was reported in accordance with the CONSORT guidelines.

Participants

Young adults aged 18–30 years with chronic smartphone use of at least ≥ 4 hours per day and clinically diagnosed mild to moderate forward head posture were recruited through advertisements in educational institutions and physiotherapy outpatient departments in and around Karad.

Inclusion criteria

- Age between 18 and 30 years
- Smartphone use ≥ 4 hours/day
- Presence of forward head posture
- Ability to follow verbal instructions
- Willingness to participate

Exclusion criteria

- History of cervical spine fracture, surgery, or major trauma
- Severe cervical or shoulder deformity
- Neurological disorders affecting the neck or upper limb
- Systemic musculoskeletal disorders (e.g., rheumatoid arthritis, advanced osteoporosis)

Participants who met the eligibility criteria underwent baseline assessment before randomization.

Sample Size Calculation

The sample size was calculated based on the primary outcome measure (neck flexor endurance) using the formula for comparison of two means. With an expected moderate effect size, a statistical power of 80%, and a significance level of 5%, the required sample size was 28 participants. To compensate for potential dropouts, 30 participants were recruited and randomly allocated into two groups (15 per group).

Randomization and Allocation Concealment

Participants were randomly assigned to either:

- **Group A – Brugger's exercise**
- **Group B – Brugger's exercise combined with hand-grip training**

Randomization was performed using a computer-generated random sequence prepared by an independent researcher who was not involved in recruitment, assessment, or intervention. Allocation concealment was ensured using sequentially numbered, sealed, opaque envelopes.

Blinding

Due to the nature of the exercise intervention, participant blinding was not feasible. However:

- The outcome assessor was blinded to group allocation
- The data analyst was blinded to group assignment

to minimize detection and analysis bias.

Outcome Measures and Assessment Timeline

All outcome measures were assessed at:

- Baseline (pre-intervention)
- After 4 weeks of intervention (post-intervention)

Primary Outcome

Neck flexor endurance test (seconds):
Measured in the supine position with chin tuck and head lifted approximately 2–3 cm from the plinth. Three trials were performed with adequate rest, and the maximum value was recorded for analysis.

Secondary Outcomes

Craniovertebral angle (degrees):
Measured using standardized lateral photographic analysis with reflective markers placed on the tragus and the spinous process of C7. The angle between the horizontal line through C7 and the line joining C7 to the tragus was calculated using digital software.

Hand-grip strength (kg):
Measured using a calibrated hand dynamometer with the shoulder adducted and neutrally rotated, elbow flexed to 90°, forearm in neutral, and wrist slightly extended. Three maximal voluntary contractions were recorded for the dominant hand, and the highest value was used for analysis.

Intervention Protocol

The intervention was administered for **4 weeks**, **5 sessions per week**, under the supervision of a licensed physiotherapist.

Group A – Brugger’s Exercise

Participants performed Brugger’s postural correction exercises in an upright sitting position emphasizing:

- Thoracic extension
- Scapular retraction and external rotation
- Gentle cervical retraction with chin tuck
- Diaphragmatic breathing

Each posture was held for 10–20 seconds with progressive loading. Three sets of 10–15 repetitions were performed per session with adequate rest between sets.

Table no 1

Phase	**Week**	**Training Goal**	**Exercise Description**	**Dosage**	**Frequency**	**Rest**
Phase I – Activation	Week 1	Postural awareness and activation of deep cervical and scapular stabilizers	Upright sitting with neutral pelvis, thoracic extension, scapular retraction and depression with external rotation, gentle chin tuck, diaphragmatic breathing	10-20second hold × 10-15 repetitions × 3 sets	5 sessions/week	30–40 sec between sets
Phase II – Endurance	Week 2–3	Improve postural endurance and neuromuscular control	Same posture with reduced external cueing and sustained correction	15-second hold × 12 repetitions × 3 sets	5 sessions/week	30–40 sec between sets
Phase III – Functional Integration	Week 4	Maintain corrected posture during functional activities	Brugger’s posture performed in simulated workstation sitting	20-second hold × 15 repetitions × 3 sets	5 sessions/week	30–40 sec between sets

Group B – Brugger’s Exercise + Hand-Grip Training

Participants performed the same Brugger’s exercise protocol as Group A in addition to hand-grip strengthening using an adjustable hand gripper:

- 3 sets of 12–18 maximal squeezes
- 1-minute rest between sets

- Progressive resistance based on individual tolerance.

Table no 2

Phase	**Week**	**Training Goal**	**Brugger’s Exercise**	**Hand-Grip Training**	**Dosage**	**Frequency**	**Rest**
Phase I – Activation	Week 1	Postural activation and initiation of distal strength	Same as Group A	Low-resistance adjustable hand gripper	Brugger’s: 10-sec hold × 10 reps × 3 sets | Grip: 3 × 12 squeezes/hand	5 sessions/week	30–40 sec (Brugger’s) 1 min (Grip)
Phase II – Endurance & Strength	Week 2–3	Improve cervical endurance and grip force	Progressed hold with minimal cueing	Moderate resistance hand gripper	Brugger’s: 15-sec hold × 12 reps × 3 sets | Grip: 3 × 15 squeezes/hand	5 sessions/week	30–40 sec (Brugger’s) 1 min (Grip)
Phase III – Functional Integration	Week 4	Functional postural control with higher distal load	Brugger’s posture in workstation sitting	High resistance / slow controlled squeezes	Brugger’s: 20-sec hold × 15 reps × 3 sets | Grip: 3 × 18 squeezes/hand	5 sessions/week	30–40 sec (Brugger’s) 1 min (Grip)

Adherence and Adverse Event Monitoring

Attendance was recorded for every supervised session. Participants who completed at least 85% of the prescribed sessions were included in the final analysis. All participants were monitored throughout the intervention period for any discomfort or adverse events. The type, severity, and management of any event were documented.

Statistical Analysis

Data were analyzed using **SPSS version 26.0**

- Normality of data → Shapiro–Wilk test
- Descriptive statistics → Mean ± standard deviation

Within-group comparison

Paired t-test was used to compare pre- and post-intervention values.

Between-group comparison

Independent t-test was used to compare mean change scores between the two groups.

Additional analysis

- Effect size → Cohen’s d
- 95% confidence interval for mean difference

The level of statistical significance was set at **$p < 0.05$**.

RESULT

Participant Flow

A total of 42 participants were assessed for eligibility, of whom 12 were excluded (8 did not meet the inclusion criteria and 4 declined to participate). Thirty eligible participants were randomly allocated into two groups: Group A (Brugger’s exercise) and Group B (Brugger’s exercise combined with hand-grip training), with 15 participants in each group.

One participant from Group A was lost to follow-up due to personal reasons, and 14 participants were included in the final analysis. All participants in Group B completed the study and were analyzed. The detailed participant flow is presented in Figure X.

Baseline Characteristics

The baseline demographic and clinical characteristics of the participants are presented in Table 3. There were no statistically significant differences between the two groups at baseline for age, gender distribution, anthropometric variables, duration of smartphone use, hand dominance, neck flexor endurance, craniovertebral angle, or hand-grip strength ($p > 0.05$),

indicating that the groups were comparable prior to the intervention.

Variable	Group A – Brugger's exercise (n = 14)	Group B – Brugger's exercise + Hand-Grip training (n = 15)	p value
Age (years)	22.4 ± 2.1	22.8 ± 2.3	0.62
Male/Female	8 / 6	9 / 6	0.91
Height (cm)	167.9 ± 6.8	168.6 ± 7.4	0.78
Weight (kg)	63.9 ± 7.9	65.1 ± 8.2	0.69
BMI (kg/m²)	22.6 ± 2.1	22.9 ± 2.4	0.74
Smartphone use (hours/day)	4.6 ± 0.5	4.8 ± 0.6	0.41
Dominant hand (Right/Left)	12 / 2	13 / 2	0.88
Neck flexor endurance (sec)	21.3 ± 5.8	21.9 ± 6.1	0.79
Craniovertebral angle (°)	43.5 ± 4.2	43.1 ± 4.5	0.82
Hand-grip strength (kg)	26.1 ± 3.9	26.4 ± 4.2	0.87

Within-Group Comparison

Group A – Brugger's Exercise

After four weeks of intervention, Group A demonstrated a statistically significant improvement in all outcome measures. Neck flexor endurance increased from 21.3 ± 5.8 seconds to 29.4 ± 6.2 seconds (mean difference = 8.1 seconds; $p < 0.001$). The craniovertebral angle improved from 43.5 ± 4.2° to 47.2 ± 4.4° (mean difference = 3.7°; $p < 0.001$), indicating a reduction in forward head posture. Hand-grip strength increased from 26.1 ± 3.9 kg to 28.3 ± 4.1 kg (mean difference = 2.2 kg; $p = 0.01$) (Table 4).

Outcome	Pre-intervention	Post-intervention	Mean Difference	p value
Neck flexor endurance (sec)	21.3 ± 5.8	29.4 ± 6.2	+8.1	<0.001
Craniovertebral angle (°)	43.5 ± 4.2	47.2 ± 4.4	+3.7	<0.001
Hand-grip strength (kg)	26.1 ± 3.9	28.3 ± 4.1	+2.2	0.01

Group B – Brugger's Exercise + Hand-Grip Training

Group B showed a statistically significant improvement in all outcome measures following the intervention. Neck flexor endurance increased from 21.9 ± 6.1 seconds to 36.7 ± 7.0 seconds (mean difference = 14.8 seconds; $p < 0.001$). The craniovertebral angle improved from 43.1 ± 4.5° to 51.2 ± 4.7° (mean difference = 8.1°; $p < 0.001$). Hand-grip strength increased from 26.4 ± 4.2 kg to 32.6 ± 4.5 kg (mean difference = 6.2 kg; $p < 0.001$) (Table 5).

Outcome	Pre-intervention	Post-intervention	Mean Difference	p value
Neck flexor endurance (sec)	21.9 ± 6.1	36.7 ± 7.0	+14.8	<0.001
Craniovertebral angle (°)	43.1 ± 4.5	51.2 ± 4.7	+8.1	<0.001
Hand-grip strength (kg)	26.4 ± 4.2	32.6 ± 4.5	+6.2	<0.001

Between-Group Comparison

Between-group analysis of the change scores revealed that the combined intervention group showed significantly greater improvement compared to the Brugger's exercise-only group (Table 6).

The mean difference in neck flexor endurance between the groups was 6.7 seconds (95% CI: 3.9 to 9.4; $p < 0.001$). The improvement in craniovertebral angle was also significantly greater in Group B than in Group A (mean difference = 4.4°; 95% CI: 1.8 to 6.9; $p = 0.002$). Similarly, hand-grip strength demonstrated a significantly higher increase in the combined group compared to the Brugger's exercise-only group (mean difference = 4.0 kg; 95% CI: 1.7 to 6.1; $p = 0.001$).

Outcome	Mean Change Group A	Mean Change Group B	Mean Difference Between Groups	95% CI	p value
Neck flexor endurance (sec)	+8.1	+14.8	6.7	3.9 to 9.4	<0.001

Craniovertebral angle (°)	+3.7	+8.1	4.4	1.8 to 6.9	0.002
Hand-grip strength (kg)	+2.2	+6.2	4.0	1.7 to 6.1	0.001

Effect Size

Between-group effect size analysis demonstrated a large clinical effect in Favor of the combined intervention for neck flexor endurance (Cohen’s d = 1.2) and craniovertebral angle (d = 0.95), while hand-grip strength showed a moderate-to-large effect size (d = 0.88) (Table 7).

Outcome	**Effect Size (d)**	**Magnitude**
Neck flexor endurance	1.2	Large
Craniovertebral angle	0.95	Large
Hand-grip strength	0.88	Moderate–Large

Adherence to the Intervention

Adherence to the intervention protocol was high in both groups. The mean number of sessions attended was 10.8 ± 1.1 in Group A and 11.4 ± 0.8 in Group B out of the 12 prescribed sessions. The proportion of participants completing at least 85% of the sessions was 85.7% in Group A and 93.3% in Group B (Table 8).

Variable	**Group A – Brugger’s exercise**	**Group B – Combined effect of Brugger’s exercise + Hand-Grip training**
Total sessions prescribed	12	12
Sessions attended	10.8 ± 1.1	11.4 ± 0.8
Participants with ≥85% adherence	12 (85.7%)	14 (93.3%)

Adverse Events

No serious adverse events were reported during the study. Mild muscle soreness was reported by two participants in Group A and three participants in Group B, which did not interfere with continuation of the intervention. Mild neck discomfort was reported by one participant in each group and was managed by temporary reduction of exercise intensity (Table 9).

Event	**Group A (n)**	**Group B (n)**	**Severity**	**Action Taken**
Muscle soreness	2	3	Mild	Continued training
Neck discomfort	1	1	Mild	Load reduced
Serious adverse events	0	0	—	—

Normality of Data

Shapiro–Wilk test confirmed normal distribution of all outcome variables ($p > 0.05$); therefore, parametric tests were used for statistical analysis.

Outcome	**p value**
Neck flexor endurance	0.21
Craniovertebral angle	0.18
Hand-grip strength	0.32

The combined Brugger’s exercise with hand-grip training produced significantly greater improvements in cervical muscle endurance, postural alignment, and hand-grip strength compared to Brugger’s exercise alone.

DISCUSSION

The present randomized controlled trial compared the effectiveness of Brugger’s exercise alone and Brugger’s exercise combined with hand-grip training on cervical muscle endurance, forward head posture, and hand-grip strength in chronic smartphone users. Both groups demonstrated significant improvements following the four-week intervention; however, the combined intervention group showed significantly greater gains in all outcome measures. These findings indicate that the addition of distal strengthening to a postural correction program provides superior improvements in cervical endurance, postural alignment, and upper-limb strength compared to postural correction alone.

Prolonged smartphone use has been consistently associated with altered cervical posture, muscle fatigue, and reduced endurance due to sustained flexed positioning and increased mechanical loading on the cervical spine.[12] The baseline findings of reduced neck flexor endurance and decreased craniovertebral angle in the present study support previous reports demonstrating a strong relationship between smartphone usage duration and impaired cervical

muscle performance.[2] Furthermore, forward head posture has been shown to increase compressive forces on cervical structures and contribute to neck pain and functional limitations.[34] The significant improvement in craniovertebral angle observed in both groups indicates that postural correction exercises are effective in restoring sagittal cervical alignment and reducing mechanical stress on cervical segments.

The improvement in cervical muscle endurance in the Brugger's exercise-only group can be attributed to activation of deep cervical flexors and scapular stabilizers during thoracic extension and scapular retraction. These findings are consistent with previous studies that reported significant improvements in craniovertebral angle and neck muscle endurance following corrective exercise programs.[5] In addition, the emphasis on postural awareness and sustained contraction likely reduced the load on passive cervical structures and improved neuromuscular control of the cervical region.[15]

The combined intervention group demonstrated significantly greater improvement in cervical endurance compared to the Brugger's exercise-only group. This additional benefit may be explained by the principle of proximal–distal neuromuscular coupling, in which enhanced distal muscle activation improves proximal stability and motor control. Distal strengthening has been shown to improve functional performance and upper-limb stability, which may facilitate more efficient activation of cervical and scapular stabilizers during postural tasks.[12] Improved grip strength in the combined group also supports previous findings that head and neck posture influences distal force production and that standardized alignment enhances grip performance.[9–11] The greater increase in hand-grip strength observed in the present study is in agreement with earlier research demonstrating the effectiveness of hand-strengthening programs in improving grip force and functional capacity.[12]

Another important finding of this study was the significantly greater improvement in craniovertebral angle in the combined group. The improved postural alignment may be attributed to enhanced scapular stabilization and improved neuromuscular coordination between the upper limb and cervical region. The role of the pectoralis minor in scapular positioning and upper-quarter posture has been well established, and postural correction exercises that reduce anterior muscle tightness contribute to improved cervical alignment.[6–8] The integration of distal strengthening likely enhanced postural endurance, enabling participants to maintain the corrected alignment for longer durations during functional activities.

The large effect sizes observed for cervical endurance and craniovertebral angle in the combined group indicate that the intervention was not only statistically significant but also clinically meaningful. These findings support the use of a multimodal rehabilitation approach targeting both proximal postural muscles and distal upper-limb strength in individuals with smartphone-related musculoskeletal dysfunction.

The high adherence rate observed in both groups suggests that the intervention was feasible and well tolerated. Only mild and transient adverse events were reported, indicating that the exercise program is safe for use in young adults.

The present study has several clinical implications. The combined Brugger's exercise and hand-grip strengthening program is simple, low-cost, and easily applicable in outpatient physiotherapy settings, educational institutions, and workplace health programs. It may be used as both a preventive and rehabilitative strategy for individuals with prolonged smartphone use and early postural deviations.

Despite the positive findings, certain limitations should be considered. The sample size was relatively small, and the intervention duration was limited to four weeks; therefore, long-term retention of postural correction and endurance gains could not be assessed. Participant blinding was not feasible due to the nature of the intervention. In addition, the study included only young adults, which may limit the generalizability of the results to other age groups or individuals with chronic cervical pathology.

Future studies with larger sample sizes, longer follow-up periods, and inclusion of different age groups are recommended to determine the long-term effectiveness of the combined intervention. Comparative studies evaluating isolated distal strengthening, isolated postural correction, and other multimodal approaches may further clarify the specific contribution of each component.

CONCLUSION

The present randomized controlled trial demonstrated that both Brugger's exercise alone and Brugger's exercise combined with hand-grip training significantly improved cervical muscle endurance, craniovertebral angle, and hand-grip strength chronic smartphone users. However, the combined intervention produced significantly greater improvements in all outcome measures compared to Brugger's exercise alone. These findings indicate that the addition of distal strengthening to a postural correction program

enhances cervical endurance, postural alignment, and upper-limb strength more effectively than postural correction performed in isolation. The intervention was well tolerated, with high adherence and no serious adverse events. Therefore, a multimodal approach incorporating both proximal postural correction and distal strengthening appears to be a more effective rehabilitation strategy for addressing smartphone-related postural dysfunction in young adults.

CLINICAL IMPLICATIONS

The findings of this study provide a simple and practical rehabilitation approach for physiotherapists managing individuals with forward head posture associated with prolonged smartphone use. The combined Brugger's exercise and hand-grip strengthening protocol can be easily implemented in outpatient physiotherapy settings, workplace ergonomics programs, and educational institutions as it requires minimal equipment, is time-efficient, and is cost-effective. The program may be used for both preventive and therapeutic purposes to improve cervical muscle endurance, correct postural alignment, and enhance upper-limb strength. In addition, the integration of distal strengthening with postural correction may improve functional performance during daily activities that involve sustained smartphone use.

LIMITATIONS

This study has several limitations. The sample size was relatively small, which may limit the generalizability of the findings. The duration of the intervention was four weeks, and therefore the long-term retention of the observed improvements could not be determined. Blinding of participants was not feasible due to the nature of the exercise intervention. The study included only young adults, and the results may not be generalizable to older individuals or those with chronic cervical pathology. Additionally, follow-up assessment was not performed.

FUTURE RECOMMENDATIONS

Future studies should include larger sample sizes and longer intervention and follow-up periods to evaluate the long-term effectiveness of the combined program. Research involving different age groups, occupational populations, and individuals with symptomatic neck pain is recommended. Comparative studies including other postural correction and strengthening protocols may help to identify the most effective rehabilitation strategy for forward head posture associated with smartphone use.

STUDY STRENGTHS

This study has several strengths. It was conducted using a randomized controlled trial design with assessor blinding, which reduced measurement bias. Both groups received a structured and progressive intervention protocol under supervision, ensuring treatment fidelity. The study demonstrated high participant adherence and minimal adverse events, indicating good feasibility and safety of the intervention. In addition, the protocol is simple, cost-effective, and easily reproducible in clinical and community settings, which enhances its practical applicability.

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