ORIGINAL ARTICLE

The Effect of Exercise Intervention on Non-Specific Neck Pain and Head and Neck Angles Among Adult Smartphone Users

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Received: 10 October 2024
Revised: 13 November 2024
Accepted: 07 December 2024

Abstract

Background: This study aimed to investigate the effect of exercise intervention on non-specific neck pain and head and neck angles among adult smartphone users.
Methods: This interventional study was conducted among 84 adults divided into experimental and control groups. Data were collected using a demographic questionnaire and the Visual Analogue Scale (VAS). Craniovertebral angle (CVA), head flexion angle (HFA), gaze angle (GA), and forward head position (FHP) were determined from photographs analyzed with Kinovea software. The corrective exercises included 10 exercises targeting the neck muscles, including flexors, deep flexors, scapulothoracic muscles, and stretching of both left and right neck muscles. The experimental group performed these exercises for 12 weeks, with five weekly sessions lasting 15 minutes each. Research variables were re-measured immediately after the intervention.
Results: 45.3% of the experimental group reported moderate neck pain severity before the intervention. Following the intervention, 33.3% of the experimental group reported no neck pain. The severity of neck pain significantly improved in the experimental group after the intervention (t=8.08, P=0.004). The greatest angle improvement was observed in GA, with a mean increase of 20.44° in the experimental group after three months (t=12.49, P=0.003). HFA (t=6.52, P=0.009) and FHP (t=12.74, P=0.007) significantly decreased in the experimental group post-intervention. Additionally, CVA showed a statistically significant increase in the experimental group (t=-11.75, P=0.004).
Conclusion: Over half of the experimental group reported reduced neck pain severity after the exercise intervention. Three months of corrective exercises significantly decreased HFA and GA while increasing CVA in the experimental group by more than 10 degrees.

Please cite this article as: Tabanfar S, Sobhani S, Safari Variani A, Varmazyar S. The Effect of Exercise Intervention on Non-Specific Neck Pain and Head and Neck Angles Among Adult Smartphone Users. J Health Sci Surveillance Sys. 2025;13(1):47-56.

Keywords: Exercise, Neck, Pain, Smartphone

Introduction

Over the last decade, the widespread use of smartphones for communication, entertainment, and internet access has caused their adoption to increase exponentially across different age groups.[1,2] In the United States, 92% of adults aged 18–34 own a cell phone, a number that rises to 95% in Australia.[3] In Iran, smartphone users grew from 2 million in 2013 to more than 52 million in 2021.[4]

The usual position for using smartphones is to hold them with one or two hands below eye level.

This posture creates a forward head posture, often maintained for prolonged periods.[1] Forward head posture is characterized by a decrease in lordosis in the lower cervical vertebrae and an increase in posterior curvature in the upper thoracic vertebrae.[5] Awkward posture and muscle fatigue while using a smartphone can lead to numbness, pain, and musculoskeletal disorders in the neck and shoulder regions.[6] A study by Vahedi et al. highlighted the impact of smartphone use on increasing neck angle and muscle fatigue.[7] When the head bends forward to varying degrees, the weight borne by the cervical spine increases dramatically. While an adult's head weighs 10–12 pounds (lb) in a neutral position, the forces exerted on the cervical vertebrae rise to 27 lb at 15°, 40 lb at 30°, 49 lb at 45°, and 60 lb at 60°.[8]

Recent research has found a direct relationship between long-term smartphone use and the development of musculoskeletal symptoms, particularly neck pain.[7, 9, 10] A study of smartphone users at a Canadian university revealed that 68% experienced neck pain.[11] Weleslassie et al. reported a prevalence of 49% among smartphone users with neck pain. The most significant factors associated with neck pain were a previous history of neck pain, physical activity, duration of use, and awkward posture.[12]

Neck pain is the fourth leading cause of disability worldwide.[13] One type of neck pain, primarily caused by mechanical disorders such as degenerative changes, is non-specific neck pain (NsNP).[14] Approximately two-thirds of the adult population suffers from NsNP .[15] NsNP is defined as neck pain without a specific underlying systemic disease and is considered multifactorial.[16] Factors such as age, poor physical health, and awkward posture contribute to the development of NsNP.[17] The incidence of NsNP has been reported to range from 12% to 70% in the general population.[16]

Conservative treatments for managing non-specific neck pain (NsNP) are numerous and include various forms of exercise, massage, and acupuncture, which have been reported to be more beneficial than drug therapy.[16, 18] Exercise therapy is "active or passive physical exercises designed to strengthen or stabilize the spine that may reduce pain, prevent injuries, and improve posture and body mechanics."[19]

Exercise therapy is one of the most important therapeutic interventions for managing neck pain, as it improves the mobility of neck structures, increases muscle strength and the tensile strength of ligaments, and prevents tendon damage.[18, 20] Additionally, exercise can help reduce pain by improving cardiovascular function and blood circulation.[21]

Despite evidence supporting the positive effects of corrective exercises in strengthening neck muscles to control pain, variables such as the type and set of movements used in research are often significantly different or not reported accurately.[22] Additionally, the effectiveness of corrective exercises on head and neck angles remains a subject of debate, particularly concerning the duration of their implementation.[17] Therefore, this study aimed to evaluate the effect of exercise intervention on non-specific neck pain and head and neck angles among adult smartphone users.

Methods

Study Design

This interventional study was conducted among willing and cooperative adults during March, April, and May 2021. Participants were initially required to complete an informed consent form briefly explaining the study process, objectives, and methods. The Ethics Committee of the University of Medicine Science approved the study protocol under the code IR.QUMS.REC.1399.374.

The study included both experimental and control groups. Data collection was carried out in two phases. In the first phase, demographic information was obtained using a questionnaire, neck pain severity was assessed using the Visual Analogue Scale (VAS), and head and neck angles (head tilt, neck tilt, gaze angle, and forward head position) during smartphone use were measured using the photogrammetric method with Kinovea software. The experimental group performed corrective exercises for three months, while the control group received no intervention.

In the second phase, the research variables—pain severity and head and neck angles—were reassessed immediately after the intervention.

Participants and Inclusion and Exclusion Criteria

Participants were selected from adults aged 18 to 65 who had used smartphones for at least three years.[13] Individuals were approached in person, and those willing to participate in the study and who met the inclusion criteria were invited to participate. The sampling method used was simple convenience sampling.

Of the 123 adults who completed the questionnaires, 23 were excluded for not meeting the inclusion criteria, and 14 declined to participate, leaving 86 participants. Two additional participants were excluded during the study due to unwillingness to continue or failure to perform corrective exercises for more than two weeks, resulting in a final sample size of 84 participants.

The participants were then randomly divided into two groups: experimental and control groups, each with 42 participants. A comparison of the Visual Analogue Scale (VAS) scores and head and neck angles between the two groups before the intervention showed no significant differences, indicating that the groups were similar at baseline.

The inclusion criteria were adults with mild or higher neck pain based on the VAS and a 12-month history of non-specific neck pain. Other inclusion criteria included at least three years of smartphone use, with a minimum of three hours per day of smartphone use; a BMI of 25 kg/m² or less; no uncontrolled vision or hearing problems; no injury or trauma to the neck region in the past six months; no congenital anomalies; and no severe surgical or neurological disorders.

The exclusion criteria included participants' unwillingness to cooperate in continuing the exercises, engaging in other sports activities simultaneously with the research's corrective exercises, experiencing accidents or injuries to the head and neck during the intervention period, failure to perform the corrective exercises for more than two weeks, or using sedative drugs.[3, 6, 23] It should be noted that the inclusion and exclusion criteria were determined using a questionnaire. All participants entered the study after completing the consent form.

Data Collection

Demographic Information

The participants completed a self-report questionnaire that included demographic (age, gender, and marital status) and anthropometric (body mass index, weight, and height) items.

Visual Analogue Scale (VAS)

The VAS is a tool used to evaluate the severity of neck pain (SNP) in individuals. This scale consists of a 10 cm horizontal line with markers at each end: one end represents 0 (no pain), and the other represents 10 (extreme or unimaginable pain). Participants mark their level of pain or discomfort on this line, and the score reflects the severity of the person's neck pain. The scale numbers were categorized as 1-3 for mild pain, 4-6 for moderate pain, and 7-9 for severe pain.[24]

Measurement of Head and Neck Angles

Three anatomical landmarks—the earlobe's tragus, the eye's corner, and the spinous process of the C7 vertebra—were identified to determine the angles.[4] To locate the C7 vertebra, participants were asked to bend and straighten their head three times. The spinous process was then palpated, and the C7 vertebra was identified at the end of the neck vertebrae.[3] The head and neck angles were measured as follows (Figure 1):

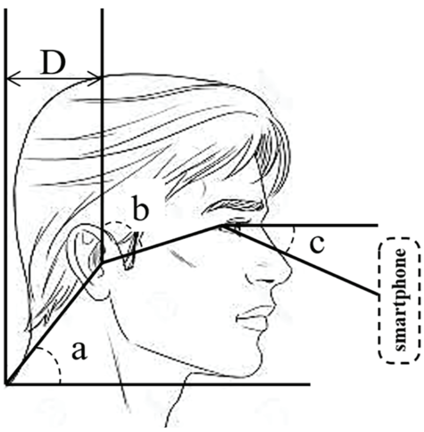
- Craniovertebral Angle (CVA/a): The angle between the line connecting the spinous process of the C7 vertebra and the tragus of the earlobe relative to the horizontal line at the level of C7. This angle has high reliability, and a higher CVA indicates a lower FHP.[4]

- Head Flexion Angle (HFA/b): The angle between the line connecting the earlobe's tragus and the eye's corner relative to the vertical line.

- Gaze Angle (GA/c): The angle between the horizontal line and the line drawn from the corner of the eye to the screen.

- Forward Head Position (FHP/D): The horizontal distance from the spinous process of the C7 vertebra to the tragus of the earlobe (Figure 1).[25]

A digital camera was placed on a tripod at a distance of 0.8 meters from the chair (a swivel chair with adjustable height and armrests). The participant sat on the chair, and the height was adjusted by the researcher so that the knee angle was 90 degrees and the soles of the feet were flat on the floor. Participants were instructed to adopt their typical sitting posture while using a smartphone. The axis of the camera lens was vertically aligned with the sagittal plane and corresponded to the height level of the C7 vertebra.[26] The participants sat comfortably on the height-adjustable chair, which was adjusted to ensure that the knee angle was 90 degrees.



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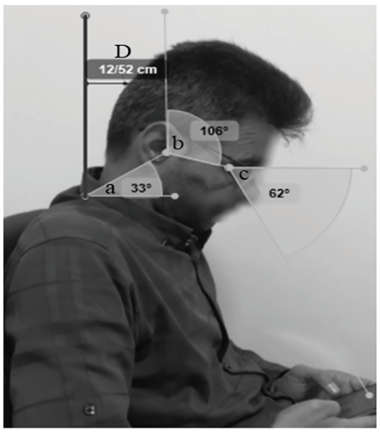

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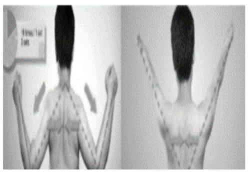
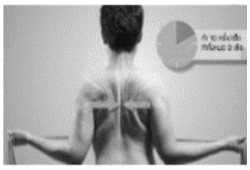
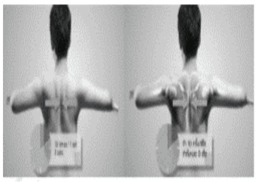
Figure 1: 1) Head and neck angles including a: Cranio-Vertebral Angle (CVA), b: Head Flexion Angle (HFA, c: Gaze Angle (GA), and D: Forward Head Position (FHP); and 2) how to measure angles in Kinova software (Pictures prepared by the author)

Table 1: Details of the Purpose and Method of Implementing Corrective Exercises [27, 28]

No.	Exercise	Description	Purpose	Cue	Example	Frequency
1	Press the chin towards the neck	Bringing the chin close to the neck and holding it	Improve Deep-cervical flexor muscle (Longus Capitis, Longus Colli, and Scalene)	Chin to neck		3 sets, each set 10 times and the rest 10 seconds between sets
2	Isometric Head Press: Forward	Place one hand on the forehead and press firmly, pressing the head against the hand to counterforce equally. Hold the rest of the body still and rigid for 10 seconds.	Improve cervical isometric strength	Firmly press head into hands.		3 sets, each set 15 times and the rest 15 seconds between sets
3	Scapular Press	Connecting the arms to the body by bending the elbows, converging and contracting the shoulders, keeping both shoulders in a "W" shape, and stretching both arms in a "V" shape	Improving and stretching the scapulothoracic muscles (rhomboid, middle and lower trapezius)	Press shoulders up and extend.		3 sets, each set 10 times and the rest 10 seconds between sets
4	Pulling out the elastic band	Connecting the arms to the body, bending the elbows 90 degrees with the body, converging and contracting both shoulders and pulling out the elastic band	Stretching the scapulothoracic muscles (middle and lower trapezius)	Keep your shoulders and neck straight		3 sets, each set 10 times and the rest 10 seconds between sets
5	Shoulder shrug with attached arm	Connecting the arms to the body by bending the elbows and converging and contracting both shoulders	Stretching the scapulothoracic muscles (middle and lower trapezius)	Press shoulders down		3 sets, each set 10 times and the rest 10 seconds between sets
6	Shoulder contraction with horizontal arm	Stretching the arms, bending the elbows 90 degrees with the plane, and converging and contracting both shoulders	Stretching the scapulothoracic muscles (middle and lower trapezius)	Keep head and neck straight and press the shoulder		3 sets, each set 10 times and the rest 10 seconds between sets
7	Lateral Flexion	Tilt head to the side towards the shoulder. Only tilt the head 45° or as far as possible without pain or discomfort. Pause and return to the neutral position. Hold the rest of the body still and rigid. Repeat on the opposite side.	Improve cervical mobility in the frontal plane. Improve Left- and right-neck muscle stretching.	Ear to shoulder		3 sets, each set 10 times and the rest 10 seconds between sets
8	Posterior neck muscle stretch	Tilt the head to the left so that the posterior neck muscle is stretched, hold the right hand to the chair, and apply pressure on the head through the left hand. Repeat on the other side.	Stretching posterior neck muscle	Chin to shoulder		3 sets, each set 10 times and rest 10 or 20 seconds between sets
9	Stretching the shoulder towards the wall	Stretching the shoulder height towards the wall, then reaching it forward, feeling the pressure on the chest, and holding it	Stretching the scapulothoracic muscles (pectoralis-minor)	Shoulder towards the wall		3 sets, each set 10 times and the rest 10 seconds between sets
10	Isometric Head Press: Backward	Sitting on a chair, connecting the back to the backrest, closing the hands behind the neck with the elbows extended and the back supported	Stretching the scapulothoracic muscles (pectoralis-minor)	"Press the head firmly into hands from behind."		3 sets, each set 10 times and the rest 20 seconds between sets

They were then asked to watch a video clip on their smartphone in their usual position, holding the smartphone in one or both hands.[23] During this time, the researcher observed the participants, and after 10 minutes of smartphone use, side images of the participants were captured. Following photogrammetry and the transfer of pictures to a computer, the angles were measured according to Figure 1 using Kinovea software version 0.8.15. Kinovea software is a reliable and valid tool for evaluating head and neck angles, as it has been used in similar studies.[26]

The Process of Implementing Corrective Exercises

The corrective exercises consisted of 10 exercises targeting the neck muscles, including the flexors, deep flexors (Longus Capitis, Longus Colli, and Scalene), and scapulothoracic muscles (Rhomboid, Pectoralis, and the middle and lower Trapezius), along with stretching exercises for the left and right neck muscles (Table 1). The sets and repetitions of the exercises were designed based on validated articles and in consultation with a specialist in corrective movements.[24, 27]

In the first session, the researcher taught the experimental group how to perform the corrective exercises through face-to-face instruction. A training video and the basic principles of the exercises were provided to the experimental group, and they were instructed to perform the exercises individually for 12 weeks, with five sessions per week, each lasting 15 minutes. The researchers maintained contact with the participants to address any ambiguities or issues that might arise during the intervention. Frequent follow-ups were conducted throughout the study to monitor the execution of the corrective exercises. The participants were also provided with timetables to track the times they performed the exercises. During this period, there was no intervention for the control group.

Statistical Analysis

Data were analyzed using SPSS version 26 software. Descriptive statistics, including numbers, percentages, means, and standard deviations, were used to summarize the study population's demographic information and the investigated variables. The normality of data distribution was assessed using the Kolmogorov-Smirnov test. A paired t-test was applied to examine the severity of neck pain and the head and neck angles before and after the intervention. Statistical significance was set at a 95% confidence level, with a P value of ≤0.05 considered statistically significant.

Results

Demographic Information

Table 2 presents the participants' demographic information in the experimental and control groups. Participants were randomly assigned to these groups. The comparison of VAS, CVA, HFA, GA, and FHP data before the intervention between the experimental and control groups showed no statistically significant difference using independent t-tests (P>0.05). The mean and standard deviation of age in the experimental and control groups were 41.74±7.55 and 42.21±7.86 years, respectively. In both groups, 40.5% of participants were male, and 59.5% were female.

The severity of Neck Pain (SNP)

Figure 2 presents the frequency distribution of qualitative SNP types before and after the intervention in both groups. In the experimental group, moderate and mild pain intensity decreased significantly after the intervention, with 33.3% of participants reporting no pain.

The quantitative SNP results before and after corrective exercises were compared using a paired t-test. In the experimental group, the mean VAS significantly decreased after the intervention (Baseline: mean=3.14, SD=1.84; After three months: mean=1.98, SD=1.84), showing a statistically significant difference (t=8.08, P=0.004). Conversely, no significant difference was observed in the control group (P=0.98).

Angles of the Head and Neck

The paired t-test results for head and neck angles before and after the intervention are presented in Table 3. The mean values for HFA, CVA, GA, and FHP in the experimental group showed significant changes after the intervention. Specifically, the mean HFA, GA, and FHP decreased while the mean CVA increased, with all changes being statistically significant.

Table 2: Demographic Information of Participants in the Experimental and Control Groups

Quantitative information			Qualitative information			
Variable	**Mean±SD**		**Variable**	**Category**	**Number (%)**	
	Experimental group (n=42)	**Control group (n=42)**			**Experimental group (n=42)**	**Control group (n=42)**
Age (yr)	41.74±7.55	42.21±7.86	Gender	Male	17 (40.5)	17 (40.5)
Height (cm)	166.33±9.38	168.31±8.00		Female	25 (59.5)	25 (59.5)
Weight (kg)	65.94±8.00	65.73±8.09	Marital Status	Single	6 (14.3)	8(19)
BMI (kg/m^2)	23.76±1.27	23.12±1.46		Married	36 (85.7)	34(81)

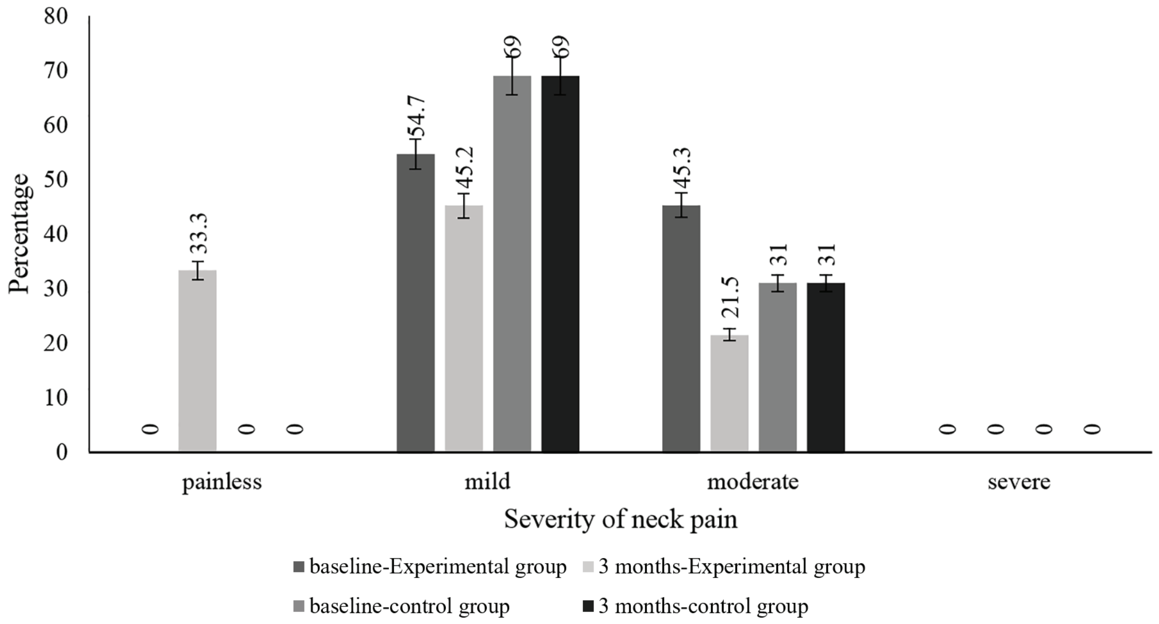


Figure 2: The severity of neck pain (qualitative) before and after corrective exercises

Table 3: Head and Neck Angles Before and After Corrective Exercises in Both Groups (n=84)

Variable	Group	Measurement Time	Mean	SD	t	P	Change relative to baseline	Correction range
HFA (degree)	Experimental	Baseline	109.21	14.36	6.52	0.009	12.46 ↓	6.79-18.13
		3 months	96.75	8.69				
	Control	Baseline	118.61	7.85	-1.47	0.147	1.06 ↑	0.94-1.18
		3 months	119.67	7.97				
CVA (degree)	Experimental	Baseline	19.45	5.52	-11.75	0.004	13.37 ↑	10.32-16.42
		3 months	32.82	8.75				
	Control	Baseline	18.95	5.5	1.73	0.090	0.59 ↓	0.57-0.61
		3 months	18.36	5.48				
GA (degree)	Experimental	Baseline	55.92	10.95	12.49	0.003	20.44 ↓	19.41-21.47
		3 months	35.48	9.92				
	Control	Baseline	50.90	9.77	-1.82	0.076	0.74 ↑	0.7-0.78
		3 months	51.64	9.73				
FHP (cm)	Experimental	Baseline	14.89	1.65	12.74	0.007	2.68 ↓	2.52-2.84
		3 months	12.21	1.81				
	Control	Baseline	15.40	1.65	-1.35	0.182	0.04↑	0.0-0.08
		3 months	15.44	1.61				

Confidence level 95% and P≤0.05, HFA: Head Flexion Angle; CVA: Cranio-Vertebral Angle; GA: Gaze Angle; FHP: Forward Head Position

At the 3-month follow-up, the experimental group demonstrated an average HFA of 96.75°, reflecting a decrease of 12.46°, and an average CVA of 32.82°, representing an increase of 13.37°. The GA exhibited the most significant change among the angles, decreasing by 20.44°. Additionally, the average FHP decreased by 2.68 cm following the intervention. In contrast, no significant differences were observed in head and neck angles within the control group.

Discussion

This study aimed to investigate the effect of an exercise intervention on non-specific neck pain and head and neck angles among adult smartphone users. The findings revealed significant improvements in both pain severity and posture-related angles (HFA, CVA, GA, and FHP) in the experimental group after the intervention. Among the angles examined, the gaze angle (GA) demonstrated the most substantial correction, indicating the pronounced impact of the exercises on head and neck posture.

In this study, participants did not report severe neck pain. However, the results revealed a significant reduction in the mean VAS score after corrective exercises in the experimental group. Additionally, the severity of neck pain in the moderate and mild categories decreased, with 33.3% of subjects reporting no pain after the intervention. These findings align with those of Fouda et al., who demonstrated the efficacy of deep neck flexor muscle-strengthening exercises in reducing pain severity among smartphone users.[29] Similarly, Agrawal et al. reported significant improvements in neck pain and disability after three weeks of deep neck muscle activation training (three sessions daily, 15 repetitions per session) in adults using smartphones.[30]

Consistent with these prior studies, this research's findings indicate that a 12-week program of corrective exercises, performed five times a week for 15 minutes per session, is an effective intervention for reducing neck pain in individuals with non-specific neck pain.

The results of this study revealed that using a smartphone in a sitting position, with the habitual practice of holding the device in one or both hands, leads to significantly inappropriate head and neck angles. These findings are consistent with the study by Vahedi et al., which demonstrated a significant relationship between the sitting position and an increased degree of forward neck flexion. The study further emphasized that smartphone use exacerbates neck flexion, particularly with both hands.[31]

This study showed a significant improvement in the mean of HFA, CVA, GA, and FHP after the experimental group intervention. Specifically, the averages of HFA, GA, and FHP decreased significantly while the CVA increased. At the 3-month follow-up, the average HFA was 96.75°, representing a decrease of 12.46°. Similarly, the CVA increased to 32.82°, showing an improvement of 13.37°, and the FHP decreased by 2.68 cm after the intervention. These findings highlight the effectiveness of the corrective exercises in improving head and neck posture among participants.

As reported in previous studies, a lower CVA is associated with a more pronounced forward head position (FHP),[32] and improving the CVA often leads to an improvement in FHP. In line with the present study, Lee et al. reported that appropriate exercises can improve CVA in smartphone users.[32] Similarly, Shete et al. studied participants aged 18-25 years, where the treatment protocol included corrective exercises and ergonomic recommendations four days a week for one month, resulting in a significant improvement in CVA.[33] In another study, Kim et al. examined the effects of deep neck flexor muscle training (three times a week for four weeks) on pain and neck and shoulder posture in patients with chronic neck pain, finding significant improvements in pain intensity and head and shoulder position after the intervention.[34] Additionally, Mendes Fernandes et al. reported that a specific neck exercise program improved neck pain and the range of motion in women with chronic non-specific neck pain.[35]

Deep neck muscles, such as the Longus Colli and Longus Capitis, play a central role in maintaining the stability of the cervical spine.[36] Strengthening these muscles effectively reduces lordosis during neck movement and prevents the forward head position caused by weakened deep flexors. A forward head posture, associated with reduced activation of the deep flexor muscles and an increased reliance on the superficial neck flexors, leads to a decreased range of motion and heightened stress on the superficial muscles.[37] In the present study, strengthening the deep neck muscles was a key aspect of the exercise intervention, which likely contributed to improving pain and head and neck positioning.

In comparing angles, the GA showed the most significant change, with a decrease of 20.44° in the experimental group after the intervention. An increase in GA reflects more neck flexion and is closely related to the CVA. Guan et al. reported that GA is positively correlated with the HFA.[25] Therefore, since these angles are interrelated, reducing the GA can help correct the cervical spine position, improve both the CVA and HFA, and reduce the incidence of neck pain.

Studies have demonstrated the effectiveness of corrective exercises in improving the GA in employees.[24] The findings of this study, along with other research in the field, despite differences in exercise types, repetition sets, and durations, consistently confirm that strengthening both the superficial and deep neck muscles can help users maintain a more desirable neck position while using a smartphone. As a result, users experience less muscle fatigue in the neck region, ultimately leading to improvements in both pain and the head and neck angles.

Conclusion

Using a smartphone while sitting, especially with the routine habit of holding it with one or both hands, places the head and neck in an inappropriate posture. The exercise intervention in this study demonstrated that a structured exercise program can reduce neck pain intensity in smartphone users and improve head and neck posture. After the intervention, the mean of HFA, CVA, GA, and FHP showed significant improvement in the experimental group. Notably, the most substantial change was observed in the GA, which decreased by 20.44° in the experimental group. In conclusion, three months of exercise intervention resulted in a significant decrease in HFA and GA and an increase in CVA by more than 10 degrees in the experimental group.

It is recommended that future studies include participants from different age ranges and that research variables be measured at multiple time points (e.g., weeks 4, 8, and 12) to understand the effects of exercise duration better. Additionally, a follow-up six months after the intervention would provide valuable insights into the long-term stability of the impact.

Future studies could also investigate the angles and posture while using smartphones in different positions, such as standing or walking. Furthermore, exploring the angle between the arm and forearm during smartphone use may help assess its role in the development and severity of neck pain.

One of the strengths of this study was the use of Kinovea software to accurately measure the head and neck angles, enhancing the precision of the data collected. However, a limitation of the study was the inability to perform electromyography (EMG) to assess muscle activity in the head and neck. Additionally, the study did not examine or compare the angles in different postures,

Authors' Contribution

Sara Tabanfar and Seyvan Sobhani conceptualized the research idea and collected and analyzed the data. Ali Safari Variani and Sakineh Varmazyar supervised the data collection and analysis and verified the methodology. Sara Tabanfar, Seyvan Sobhani, and Sakineh Varmazyar contributed to drafting, writing, and editing the manuscript. All authors have read and approved the final manuscript for publication.

Acknowledgment

The authors would like to express their sincere gratitude to all the participants in this study for their cooperation and contribution. The Ethics Committee of the University of Medical Science (IR.QUMS.REC.1399.374) approved the study protocol.

Funding

This study did not receive any funding.

Conflict of Interest: None declared.

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