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Does smartphone addiction affect cervical mobility, head posture, body awareness and pain pressure threshold?

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ABSTRACT

Aims: With the rapid development of technology, the increasing use of smartphones has become a subject of concern due to its multifaceted effects on the cervical spine and body awareness. The present study investigates effects of smartphone addiction on general cervical/isolated upper cervical mobility, body awareness, head posture, and cervical pain pressure threshold (PPT).

Methods: This prospective and cross-sectional study was conducted on 108 participants, categorized as heavy users and light users based on daily smartphone use. General cervical / isolated upper cervical mobility (right and left rotation), body awareness, head posture, and PPT (midpoint of the upper trapezius muscle, and 2 cm lateral to the C2 spinous process) were assessed using the Cervical Range of Motion Device (CROM), the Body Awareness Questionnaire, craniovertebral angle, and an algometer, respectively. The comparison of cervical mobility, head posture, body awareness, and pain pressure threshold between the groups was performed using the Independent samples T test.

Results: The results showed that smartphone addiction significantly affects isolated upper cervical mobility in the directions of right and left rotation ($p<0.001$), head posture ($p<0.001$ for both directions), and body awareness ($p=0.035$), but has no significant impact on general cervical mobility in terms of right and left rotation ($p=0.847$, $p=0.848$) or PPT assessed at two different points ($p=0.165$, $p=0.213$), respectively.

Conclusion: This study highlights the clinical implications of smartphone overuse on upper cervical mobility, head posture, and body awareness, independent of pain pressure threshold and general cervical mobility. Clinicians should assess these factors in individuals with smartphone addiction, as early intervention may help prevent long-term dysfunction and sensorimotor disturbances.

Keywords: Smartphone, cervical vertebrae, range of motion, pain, posture

INTRODUCTION

With the rapid development of information and communication technologies, smartphone usage is increasing.[1,2] When using smartphones, users tend to hold their head and neck forward more often.[3-5] Common issues observed in smartphone users include anterior head positioning and rounded shoulders.[6-8] Although the literature has explored the relationship between smartphone usage and cervical posture, few studies have addressed this relationship, and none have specifically examined the lower and upper cervical postures separately. However, considering the cervical region as comprising both lower and upper segments is essential for understanding cervical mobility and compensation mechanisms.[9]

In long-term smartphone users, forward head posture, defined as anterior positioning of the head in the cervical spine, is one of the most common postural deviations in the sagittal plane. The anterior positioning of the head leads to flexion in the lower cervical region while increasing extension in the upper cervical region.[10,11] Consequently, the neck extensors become tight and shortened, whereas the neck flexors become elongated and weakened. These changes in cervical muscles result in abnormal cervical stress.[12] These alterations can affect proprioception by altering the threshold levels of mechanoreceptors responsible for proprioception, thereby impairing proprioceptive awareness.

The cervical region is crucial for postural stability.[13] Due to the abundance of mechanoreceptors in the suboccipital muscles, the cervical region is a major source of proprioceptive information.[14] Additionally, the upper cervical region is closely connected to the central nervous system, vestibular system, and visual system.[15,16] Because of these connections, changes in the cervical spine can impact sensory integration, resulting in proprioceptive deficiencies.[17] In the literature, no previous studies have addressed the effects of smartphone addiction (SPA) on body awareness. In recent years, body awareness

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has emerged as a prominent topic in scientific research within the health field. Body awareness fundamentally refers to an individual's consciousness of their body parts or dimensions. From a neuroscience perspective, body awareness involves the brain's recognition of messages received from other parts of the body and from the external environment. These messages include not only information about the body's own movements (interoceptive or corporeal awareness) but also details about external objects, such as their properties and locations (exteroceptive or extra-corporeal awareness). Over time, this information and experience blend to form the body's perceptual experiences. These experiences are crucial for understanding and interpreting one's own body and surroundings, and for establishing social interactions. Therefore, body awareness involves having knowledge about one's own body and the properties of surrounding objects.[18] Considering the potential impact of SPA on proprioception, it is important to investigate deviations in body awareness. In light of the above information, determining the disruptive impact of SPA on body awareness is of critical importance.

The aim of this study is to investigate the effects of SPA levels on general cervical mobility, isolated upper cervical mobility, head posture, body awareness, and cervical pain pressure threshold.

METHODS

Study Design

The study, planned as a prospective, observational, cross-sectional study, received ethical approval from the Atılım University Non-interventional Clinical Researches Ethics Committee (Date: 24.01.2024, Decision No: 604.01.02-160). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. After providing information about the study to the participants, those who voluntarily agreed to participate were included in the study upon obtaining their written consent. This study was written in accordance with the STROBE checklist.[19]

Participants

The participants were recruited from the staff located on the Atılım University campus. They were invited to participate through a recruitment flyer containing information about the study, which was posted on the announcement page of Atılım University. Individuals who met the inclusion criteria and volunteered, between January/2024 and July/2024, were included in the study. The participants underwent a one-time, face-to-face evaluation by research assistant at the research laboratory of the department of physiotherapy and rehabilitation. The evaluator was unaware of the participants' group assignments during the assessment, thus ensuring blinding from the evaluator's perspective.

The inclusion criteria were being a smartphone user and being between the ages of 18 and 25. The exclusion criteria included neck pain, radicular pain, neurological symptoms, a history of cervical or upper extremity surgery, and cervical trauma. Flow chart is shown in Figure 1.

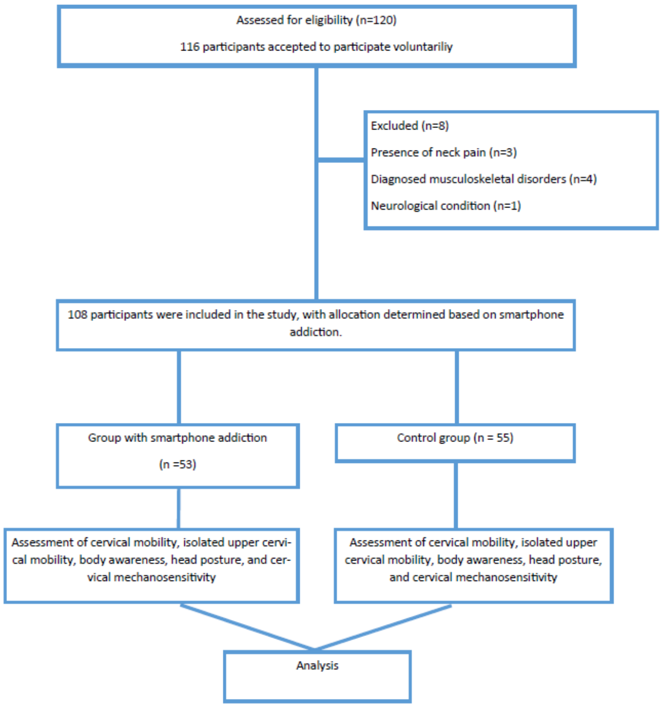

Figure. Study flow chart

In the study, individuals divided into two groups based on their smartphone usage: the experimental group (those using their smartphones for more than 4 hours per day) and the control group (those using their smart phone for less than 4 hours per day). Participants who used their smartphones for more than 4 hours per day were classified as smartphone addicts and included in the experimental group.[8,20]

Data Collection

Assessments were conducted by a researcher who was unaware of the participants' group assignments, ensuring a single-blind design for the study. In the first part of the study, participants were asked to complete a 'body awareness questionnaire', answering all questions face-to-face. In the second part, participants were invited in person for evaluations of general cervical/upper cervical mobility, sagittal head posture, and PPT.

Sociodemographic characteristics assessment: Participants' sociodemographic characteristics, including age, height, weight, body mass index was recorded in the assessment form.

Determining smartphone usage levels: Researchers categorized participants based on their daily smartphone usage into light users (those using the phone for less than 4 hours per day) and heavy users (those using it for more than 4 hours per day).[8,20] To determine smartphone usage times, an application that objectively measures daily phone usage (Screen Time) was used. Participants were instructed to download the application to their smartphones and use it for a period of one month. This application recorded the participants' daily mobile phone usage times. The average daily usage was recorded at the end of one month., and mobile phone addiction was assessed based on this data. Consequently, the classification of participants as light or heavy users was based on directly observable data, ensuring a scientific foundation rather than relying on subjective reports.

Assessment of body awareness: Body awareness was assessed using the Body Awareness Questionnaire designed to determine normal or abnormal sensitivity levels in body composition.[21] The questionnaire consists of four subgroups: 1) Changes in body processes, 2) Sleep-wake cycle, 3) Prediction of disease onset, and 4) Prediction of body responses, with a total of 18 items. Participants were asked to rate each item using a scale from 1 to 7. It has a minimum score of 18 and a maximum score of 126, with higher scores indicating greater body awareness. The validity and reliability of this questionnaire have been reported to be high.[22]

Assessment of head posture: Head posture was assessed using photographic methods and craniovertebral angle. The craniovertebral angle is calculated as the angle between a horizontal line passing through C7 and a line extending from the tragus of the ear to C7.[23] An angle less than 49 degrees indicates an anterior head position.[4]

A profile photo of the participant in a relaxed standing posture was taken. For the photograph, the camera was placed on a tripod 0.8 meters from the participant, with the camera lens axis perpendicular to the participant's sagittal plane and at a height corresponding to the level of the C7 spinous process.[24] Craniovertebral angles were calculated using the images uploaded to a computer program.

Assessment of cervical pain pressure threshold: The cervical PPTs were assessed using a mechanical pressure algometer (Baseline Force Gauge Model 12-0304; Baseline, NY, USA). A force was applied perpendicularly to a 0.5 cm² area at an approximate rate of 3 N/s. While the patient was seated, pressure was applied at the midpoint of the upper trapezius muscle, and 2 cm lateral to the C2 spinous process bilaterally.[25] For each area, two measurements were taken at intervals, and the average of these measurements was calculated to determine the final value.

Assessment of general cervical mobility: Cervical mobility was assessed using the Cervical Range of Motion (CROM) deluxe device, developed by the University of Minnesota. The CROM device is an inclinometer system that utilizes gravity and magnetic effects.[26] It is validated for accuracy and reliability. The device consists of two fixed inclinometers for the sagittal and frontal planes, a horizontal inclinometer with a magnetic needle mounted on the top of the device, a magnetic neck brace, a scale-equipped arm with a ruler mounted on the top, and a vertebra locator arm with a weighing system.

The device is designed in a plastic frame and is positioned over the nose and ears. When properly placed, the device has two fixed vertical inclinometers at the front that measure lateral flexion, and the left side measures flexion-extension. The horizontal inclinometer with a magnetic needle mounted on the top of the device evaluates rotation while the magnetic neck brace eliminates the effects of thoracic movement on rotation.

Assessment of upper cervical mobility: The CROM device was securely attached to the participant's head while they lay supine on a treatment table. The evaluator asked the participant to relax while the neck was brought to its maximum cervical flexion. In the full flexion position, the head and neck were passively rotated as far as possible within the limits of comfortable pain or physiological stiffness. The procedure was repeated twice on each side with a 30-second rest between tests. The sensitivity of the flexion-rotation test was found to be 91%, its specificity 90%, and its overall diagnostic accuracy 91%.[26] The cervical flexion-rotation test is an important tool in identifying movement impairment at the C1/2 segment[26] and can be used accurately and reliably even by inexperienced examiners.[27]

Sample size calculation: In our study, the criterion of upper cervical mobility was taken as the basis in the power analysis evaluation. According to the post-hoc power analysis, at a 5% significance level ($\alpha<0.05$) and with an effect size of 0.5, the power of the study was calculated as 80%.

Statistical Analysis

The analyses were conducted using IBM SPSS Statistics 23 software package (IBM Corporation, Armonk, NY, USA). For the evaluation of the study data, frequencies (count, percentage) were provided for categorical variables, and descriptive statistics (mean, standard deviation) were provided for numerical variables. The normality assumptions of numerical variables across groups were examined using appropriate Shapiro-Wilk or Kolmogorov-Smirnov tests. Since the data met the criteria for normal distribution, an independent samples T test was utilized.

RESULTS

Demographic information of the participants is shown in Table 1. The participants' height, weight, and body mass indices were similar ($p>0.05$). On the other hand, there was a significant difference between groups regarding age and daily smartphone usage time ($p<0.05$).

Table 1. Demographic characteristics of the participants

	Group with smartphone addiction x±SD (min; max) (n=53)	Control group x±SD (min; max) (n=55)	p-value
Age (year)	22.12±1.21 (20; 25)	22.81±2.1 (20; 30)	0.046*
Height (cm)	1.69±0.08 (1.53; 1.84)	1.7±0.09 (1.54; 1.9)	0.595
Weight (kg)	66.89±11.1 (46; 84)	65.86±11.74 (43; 94)	0. 644
BMI (kg/m²)	23.1±3.08 (17.5; 30.8)	22.45±2.73 (17.2; 27.7)	0.248
Daily smartphone usage time (h/day)	5.62±1.14 (4.1; 8)	2.53±0.92 (1; 3.9)	<0.001*

n: Number of participants, BMI: Body-mass index, SD: Standard deviation, Min: Minimum, Max: Maximum, cm: Centimeter, kg: Kilogram, kg/m²: Kilogram/meter², h/day: Hours per day

There were significant differences between the groups in terms of isolated upper cervical mobility, craniovertebral angle, and body awareness ($p<0.05$). However, there were no differences between the groups regarding general cervical mobility or cervical PPT ($p>0.05$), as shown in Table 2.

Table 2. The comparison of cervical mobility, head posture, body awareness, and pain pressure threshold between groups						
	Group with smartphone addiction (n=53)	Control group (n=55)	Mean difference	95% Confidence interval of the difference		p value[t]
	x±SD	x±SD		Lower	Upper	
Mobility of upper cervical region (right rotation)	33.41±4.38	43.7±2.87	-6.9	-7.7	-4.87	<0.001*
Mobility of upper cervical region (left rotation)	37.94±4.17	44±2.58	-6.05	-7.39	-4.72	<0.001*
Mobility of general cervical region (right rotation)	46.73±17.76	49.35±18.47	-0.68	-7.66	6.29	0.847
Mobility of general cervical region (left rotation)	49.35±18.47	48.69±17.63	0.66	-6.22	7.55	0.848
Body awareness	78.64±16.52	85.65±17.57	-7.01	-13.52	-0.49	0.035*
Pain pressure threshold (C2)	3.06±1.3	4.83±9.12	-1.76	-4.26	0.73	0.165
Pain pressure threshold (upper part of trapezius)	3.39±1.07	4.11±1.53	-0.31	-0.82	0.18	0.213
Craniovertebral angle	48.16±5.4	52.96±4.69	-4.79	-6.73	-2.85	<0.001*

*p<0.05, n: Number of participants, [t]: Independent Samples T test, SD: Standard deviation

DISCUSSION

The results of this study demonstrate that, particularly among heavy users, long-term smartphone use significantly affects isolated upper cervical mobility, head posture, and body awareness, while it has no significant impact on general cervical mobility or pain threshold. This study is the first to examine the effects of SPA on both general cervical mobility and isolated upper cervical mobility. In previous studies, cervical mobility was evaluated as a whole, whereas this study separately assessed the lower and upper cervical regions. By comprehensively addressing the impact of SPA on musculoskeletal and sensorimotor functions, this study provides valuable insights into the consequences of excessive smartphone use in young adults. This comprehensive approach offers a deeper understanding of how SPA affects the cervical region and awareness processes.

In the present study, the smartphone addiction group and the control group were similar in terms of height, weight, and body mass index. However, when the ages of the participants were statistically compared, individuals in the control group were observed to be older. Age is known to be associated with forward head posture and mobility limitations. Although the control group was at a higher risk for forward head posture, younger individuals in the smartphone addiction group were found to have a greater craniovertebral angle. Similarly, this applies to upper cervical mobility and body awareness. As a result, the age variable did not affect the outcomes for parameters with significant findings. However, it may have obscured the results related to pressure pain threshold and total cervical mobility, where no significant difference was found between the two groups. This should be considered in future studies. In long-term smartphone users, forward head posture, defined as the anterior positioning of the cervical spine, is one of the most common postural deviations in the sagittal plane. According to previous studies, this postural change, characterized by decreased craniovertebral angle, is significantly more pronounced in individuals with SPA.[27-29] The findings of the present study are consistent with previous research, confirming that forward head posture is significantly increased in those with SPA. This result further substantiates the negative impact of prolonged smartphone use on cervical posture. From a clinical perspective, it underscores the need for awareness and the development of ergonomic training programs aimed at preventing head and neck postural issues related to smartphone usage.

The results showed that while isolated upper cervical mobility was significantly affected in individuals with SPA, general cervical mobility did not show a significant change. Specifically, in heavy smartphone users, isolated upper cervical mobility was markedly reduced compared to the control group, independent of general cervical mobility. Upper cervical mobility was assessed using the flexion-rotation test and the CROM device for both right and left rotation. This method of evaluating isolated upper cervical mobility is considered valid and reliable in the literature. While previous studies have focused on the effects of SPA on general cervical mobility, the present study is the first to specifically address the isolated upper cervical region.

This finding suggests that the reduction in upper cervical mobility plays a significant role in limiting upper cervical range of motion due to prolonged smartphone use. Therefore, developing specific therapeutic approaches aimed at preserving and improving upper cervical mobility in individuals with SPA is of great importance in clinical practice.

Another parameter we examined in individuals with SPA in the present study was body awareness. There is only one study investigated effect of SPA on body awareness.[30] According to the results of our study, there is a significant impairment in body awareness among heavy users. This underscores the critical importance of developing awareness training and rehabilitation approaches aimed at improving body awareness in individuals with SPA from a clinical perspective.

Another topic investigated in the present study is the effect of SPA on cervical PPT. Cervical PPTs were measured bilaterally using a mechanical pressure algometer at the lateral sides of the 2nd cervical spinous process and at the midpoint of the upper trapezius muscle. According to the results of the present study, cervical PPTs were similar in individuals with and without SPA. This finding is consistent with previous studies in the literature.[31] One of the factors that may have contributed to the lack of a significant difference in pressure pain threshold between the two groups is the exclusion of individuals with pain from the study. Individuals with pain and smartphone addiction were not included in the study, as the presence of pain is also associated with forward head posture and could have masked the effects of smartphone addiction. This should be taken into consideration in future studies. Our findings suggest that SPA does not have a significant impact on cervical PPTs, and that cervical dysfunctions related to smartphone use may be more closely associated with posture and upper cervical mobility. Therefore, in clinical practice with individuals who have SPA, focusing on postural and mobility issues rather than PPT may be more beneficial.

Limitations

This study has several important limitations. First, the sample consists only of young individuals. Future studies involving broader age groups and individuals with different health conditions could assess the effects of SPA on cervical mobility, posture, body awareness, and pain threshold. Second, long-term follow-up studies in the future may provide insights into the time-dependent effects of SPA on cervical dysfunctions. Finally, PPTs measurements were taken from only two regions. Future studies could collect data from more regions and use different methods, such as pain tolerance.

This study comprehensively examined the effects of SPA on cervical mobility, head posture, body awareness, and cervical PPTs. It is the first study to specifically investigate the effects of SPA on isolated upper cervical mobility, making a significant contribution to the literature. Additionally, the methodologies used in this study were evaluated with valid and reliable measurement tools, which suggests that the findings are also clinically relevant.

CONCLUSION

This study provides important insights for clinical practices aimed at preventing and treating postural and mobility disorders related to SPA. The findings suggest that long-term smartphone use may lead to a decrease in isolated upper cervical mobility and impairments in body awareness, highlighting the need for rehabilitation programs to focus on these areas. In individuals with SPA, treatment approaches incorporating awareness training and specific mobility exercises could enhance clinical outcomes.

Future studies should include broader age groups and individuals to assess the effects of SPA. Additionally, long-term follow-up studies could provide valuable data on the time-dependent postural and neuromuscular changes related to SPA. Future research could also explore pain threshold more extensively by evaluating additional regions and using different methods, helping to better understand the impact of SPA on this parameter.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Atılım University Non-interventional Clinical Researches Ethics Committee (Date: 24.01.2024, Decision No: 604.01.02-160).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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