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The Changes in the Neck Flexion Angle in Relation to Smartphone Duration Usage among Umm AlQura Female Students

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ABSTRACT

Background: The usage of smartphones plays a significant role in everyday life, and smartphone addiction is significantly associated with musculoskeletal complications due to prolonged use with the maintenance of neck flexion posture. Purpose: To quantitatively assess the changes in the neck flexion angle of smartphone users in relation to the duration of usage.

Method: Thirty female participants from Physical Therapy department at Umm AlQura University with ages ranged from 18 to 24 years were recruited. The participants were randomly assigned (1:1) to one of two groups, one of which performed browsing and texting tasks while standing and the other while sitting against a scaled board for 25 minutes. The experiment required only one session to observe the participants neck flexion angle variations and a photo was taken every 5 minutes from the beginning to the end of the session.

Results: Neck flexion angle was significantly affected by the posture and different duration of usage, and the comparison of neck flexion angle in sitting and standing position revealed a significant difference in all durations except 10-25 minutes in the standing group. Study results suggest that sitting, which is the most frequently used position, may be a main contributing factor to the occurrence of musculoskeletal symptoms among heavy smartphone users.

Conclusion: The findings revealed statistically significant effects of both posture and usage duration on neck flexion angle. Also, neck flexion angle increased significantly over time in all postures.

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INTRODUCTION

The smartphone is a portable device that running a complete operating system in a manner like a traditional computer and mobile functions and facilitate several tasks for users, including information sharing, email sending and receiving, chat, document opening and editing, product payment, learning, browsing, and shopping [1]. People around the world have adopted this new and exciting technology as one of the most crucial required facilities in their everyday life, according to a recent study [2].

A previous study conducted at Najran University revealed a current phenomenon of trends in smartphone usage among university students in Kingdome of Saudi Arabia (KSA). The findings of this study suggest that smartphones have been used as a digital camera as 75.2% and 63.4% of participants have used smartphones for taking photos and videos. The smartphone has also become a means for social networking as 91.92% of participants have used smartphones for the purpose [3].

KEYWORDS:
Smartphone overuse,
Neck flexion angle,
Posture,
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Smartphone addiction is the overuse of smartphones to the point where it interferes with users' daily life [4]. In a recent study conducted in all provinces of KSA from December 2015 to June 2016 to detect addiction to smartphone usage in the student population and its relation to health and daily activities, the results showed that the prevalence of smartphone addiction was 19.1%. Female participants were more addicted than male participants ($P < 0.001$) [5].

Interactive smartphone applications may increase the risk for developing a smartphone addiction among university students, and as a result, there are numerous studies have shown how smartphone addiction affects physical activity, body pain, and sleep quality [6].

A study from the United State of America (USA) [7], and Korea [8] reported that excessive smartphone use had a negative association with students' physical health. Several studies showed that overusing smartphones could be related to increasing complaints of pain in neck and upper extremity among university students [9,10,11].

Smartphone addiction was also significantly associated with musculoskeletal complications, upper limb problems, eyes disorders, and sleep disturbances. There was a study investigating the musculoskeletal disorders in smartphone users in Thailand to confirm the high prevalence of neck pain with the result showing the most painful body region after the use of smartphones over 12 months was found to be the neck (32.50%) [12].

One of the factors that affect muscle activity and neck posture is the size of the screen. Smaller screen sizes result in deeper neck bending to overcome the distance between eyes and screens. While in the other hand, a larger screen means a higher weight of the device which may cause fatigue to the arm and shoulder muscles while holding the device. The type of task performed also has an effect; the difficulty of the task is not the only determinant; different visual and physical interaction requirements could change the magnitude of neck flexion while using the phone [13,14].

Playing video games and texting has higher neck muscle activation with no difference between them; but in neck flexion angle it does differ, texting task has a larger neck flexion angle [13]. Additionally, texting type, increasing forearm and thumb muscles activities level have been found during unilateral texting. Also holding a phone and texting with the same hand led to increased activity levels of shoulder and forearm muscles. Compared with bilateral texting, larger amplitude, and more repetitive thumb movements are involved in unilateral texting, resulting in higher muscle activity in the thumb [15]. In Saudi Arabia, the statistics depicts the smartphone penetration as share of the population from 2017 to 2025. In 2019, 80.7 percent of the population in Saudi Arabia used a smartphone and it is projected to reach to 97 percent of population in 2025 [16]. However, there are limited studies about smartphone addiction and its impacts on physical health among university students in Saudi Arabia. Therefore, this study aims to fill this gap by comparing the effect of position on increase of neck flexion angle, analyzing the association of prolonged use of smartphone use and upper extremity and neck pain, and determine which position and which time is more projected to increase the neck flexion angle.

METHODOLOGY

Adherence to Ethical Guidelines

The study was evaluated and ethically approved by the Institutional Review Board of Umm AlQura University in Makkah, Saudi Arabia. Approval No. (HAPO-02-K-012-2023-02-1462).

Participants

Thirty young female participants ranging from 18 to 24 years old, with normal class of body mass index (BMI), and who did not have any physical discomfort on the neck and neighboring body regions were recruited from Physical Therapy Department at Umm al-Qura University. All participants experienced at least three years of smartphone usage and an average of 3 hours of usage per day. The participants signed an informed consent form. after being informed of the study's purpose.

Procedure

Participants were randomly divided into two groups (sitting posture group and standing posture group), 10 participants for each posture. For the sitting posture group, each participant conducted a smartphone task using her smartphone freely but continuously for 25 minutes while sitting on a chair with the hip and knees flexed at 90° against a scaled board. The participants were not allowed to adjust the sitting posture, but they were allowed to briefly extend the head during the task. For standing posture, the same duration as in sitting but standing against a scaled board. The participants weren't allowed to modify their standing posture or shift their weight from one foot to another.

Prior to photographic analysis procedure, a reflective marker from styloid process of temporal bone and over C7 spinous process were determined to measure the neck flexion angle, the angle between a vertical line passing through C7 and a line extending from the styloid process of temporal bone to C7 was calculated.

The measuring tool for the neck flexion angle is ImageJ software (Version 1.54d) running on the personal computer. It is a software designed with JAVA language and developed for image processing and analysis by National Institute of health (NIH), the software has a function to calculate the angle between two segments and digitizing function to conduct 2D and 3D analysis, as well as it measures the distances. ImageJ software has the advantage that it can be installed in many operating systems [17].

Data collection

Data was conducted by using a pre-experiment questionnaire for collecting demographic data about the participant's age, height, and weight and some questions about the smartphone user experience to include and exclude the study sample. And another post questionnaire to conduct their opinion about which duration they felt the most discomfort or pain and where they felt it (region of body).

For each participant neck flexion angle was recorded continuously for 25 minutes, first at 0 minutes duration of beginning of usage then 5 minutes, 10, 15, 20, and 25 minutes.

Outcome measures

Neck flexion angle while sitting and standing at different times (0,5,10,15,20, and 25 minutes).

Statistical analysis

For statistical computation and analysis, the SPSS program software (version 16.0; SPSS Inc, Chicago, IL) was used. The Shapiro-Wilk test was used to determine the normality of the data. The data was presented in the form of a mean and a standard deviation. Within-group comparisons of mean variations in neck flexion angle in sitting and standing positions were tested using a paired t-test. To assess the difference between groups, an unpaired t-test was used. The value probability was set to P<0.05.

RESULTS

Demographic characteristics

Tables (1) show the demographic characteristics of all participants from both groups, with no significant differences in age or body mass index (BMI) found between the two groups.

Table 1. Demographic and clinical characteristics of participants at baseline.

Character	Standing posture group	Sitting posture group	P-Value
	Mean ± SD	Mean ± SD	
Age (years)	21.6 ± 1.07	20.70 ± 1.25	0.019**
BMI (kg/m2	20.2 ± 2.02	21.64 ± 1.86	0.024**

** Non-Significant SD: standard deviation

Table 2. Mean values of neck flexion angle in the sitting and standing position.

Posture	Duration of usage in minutes	Mean ± SD
Standing	0	46.58 ± 10.17
	5	51.21 ± 10.21
	10	54.71 ± 10.69
	15	55.64 ± 10.55
	20	56.09 ± 11.00
	25	57.78 ± 11.26
Sitting	0	54.12 ± 6.07
	5	58.09 ± 5.79
	10	59.09 ± 6.88
	15	60.30 ± 6.85
	20	63.08 ± 6.09
	25	63.49 ± 6.64

Participants' features of smartphone usage

Table (3) illustrates smartphone usage characteristics. Most participants (90%) had used a smartphone for more than 6 years.

Table 3. Summary of pre-experiment and post experiment questionnaires

	Item	Percentage	
Pre-experiment			
	Years of using smartphone		
	From 3 to 6 years	10%	
	More than 6 hours	90%	
	Hours/day of using smartphone		
	From 1 to 3 hours	10%	
	From 3 to 5 hours	10%	
	More than 5 hours	80%	
Post- experiment			
	Time at which feeling fatigue started	Standing	Sitting
	Last 10 minute	60%	60%
	After 10 minutes	20%	30%
	After 5 minutes	20%	10%
	Region at which pain felt in	Standing	Sitting
	Upper back	30%	40%
	Middle of the back	10%	40%
	Back	20%	10%
	Others	40%	10%

Neck flexion angle within groups

One way analysis of variance (ANOVA) was conducted to determine if the neck flexion angle within each group (standing and sitting) was affected by different duration of usage (0, 5,10,15,20, and 25 minutes). The results indicate that the neck flexion angle was affected by posture and duration as shown in Table (4).

Table 4. Results of analysis of variance (one way-ANOVA) in the sitting and standing position during different duration of usage.

Posture	F-value	P-value
Sitting	5.88	0.0001**
Standing	2.96	0.015**

* Non-Significant ** Significant

Neck flexion angle

Comparison of neck flexion angle in sitting and standing position revealed a significant difference in all durations except 10-25 minutes in the standing group as shown in Table (5) and Figure (1).

Table 5. Results of T-test for comparing the neck flexion angle within group and with specified duration.

Posture	Duration	P-value
Standing	At rest - 10 min	0.0184**
	10 - 25 min	0.382*
Sitting	At rest - 10 min	0.020**
	10 - 25 min	0.0465**

* Non-Significant ** Significant

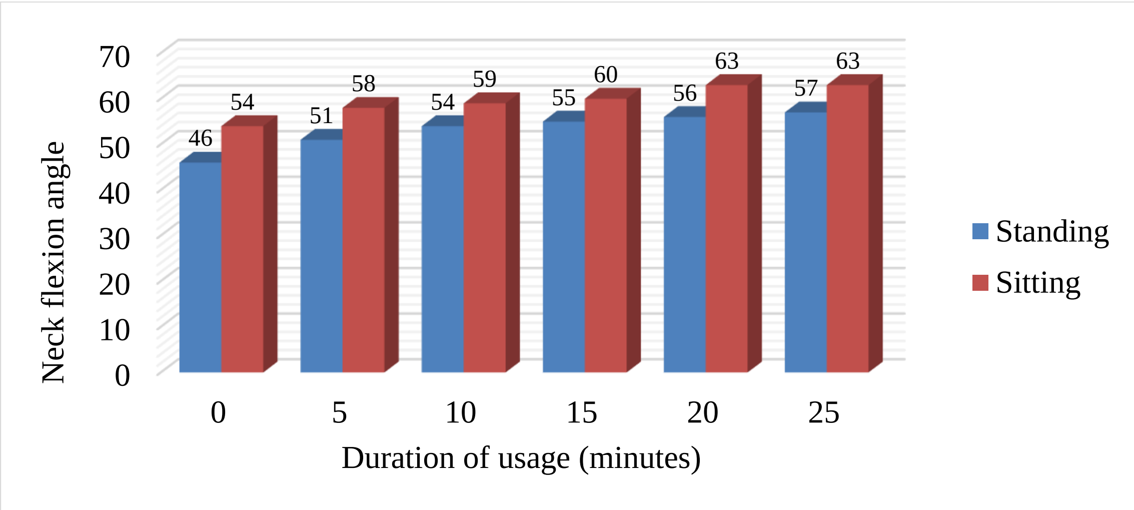

Figure 1. Mean values of neck flexion angle in the sitting and standing position

Neck flexion angle between groups

Comparison of neck flexion angle in sitting and standing position revealed a significant difference in all durations except Between 10 sitting and 10 standing and between 15 sitting and 15 standing as shown in Table (6).

Table 6. Comparison the neck flexion angle between groups

Compare between	P-value
Between 0 at sitting and 0 at standing	0.0071**
Between 5 at sitting and 5 at standing	0.0125**
Between 10 at sitting and 10 at standing	0.132*
Between 15 at sitting and 15 at standing	0.105*
Between 20 at sitting and 00 at standing	0.0174**
Between 25 at sitting and 25 at standing	0.0582*

* Non-Significant ** Significant

DISCUSSION

The aim of this study was to investigate and examine changes in the neck flexion angle while using a Smartphone based on posture and duration of usage. The experiment results showed that both posture and duration of usage have a significant effect on neck flexion angle; standing posture provided the smallest flexion angle, and the angle increased continuously over time during the 25-minute experiment.

High frequent usage of smartphones is thought to cause a variety of issues, such as high risk of addiction. Moreover, Smartphone over usage had a major impact on everyday activities, sleeping disorders, and health problems [5]. it may cause musculoskeletal symptoms in various parts of the body, including the neck, shoulders, elbows, wrists, fingers, and back.

A previous study revealed that high frequency of mobile phone use could be a marker for developing sleep disturbances, they found a strong and significant relation between sleep problems and smartphones addiction. Most common sleep complication among the high-risk group was feeling sleepy during work (34.8% of their participants) [5]. And another recent study conducted medical students confirms to findings of Alkhateeb et al. found that a huge percentage (51.3%) of their participants reported poor quality of sleep and rest, this finding may be attributed to longer average of screen time usage. [18]

Long-term use of a smartphone can also lead to bad posture such as forward-neck flexion, a slouched position, or rounded shoulders [19]. Continuous forward neck posture can harm ligaments and the cervical and lumbar spine's structural integrity. These structural issues brought on by poor posture can also cause respiratory impairment [20,21].

The functionality of the respiratory system is influenced by the position and the amount of time spent using smartphones, leading to restricted chest expansion and affecting the breathing system. Improper sitting posture and limited mobility in the cervical thoracic region can affect breathing mechanics, this in turn, can lead to changes in the diaphragm function and instability in the core muscles if left unchecked, this can ultimately result in musculoskeletal disorder [21].

A previous study [21] evaluated the changes in posture and respiratory function depending on smartphone usage was found significant differences in peak expiratory flow. Another previous study [20] revealed that there is a significant difference in forced vital capacity and forced expiratory volume between control group and smart phone user group. These findings

proves that prolonged smartphone use has a harmful effect on posture and breathing system.

Another aspect of exposure is the impact of smartphones overuse on musculoskeletal system. Several studies have shown that the less physical activity and body pain and discomfort were related to smartphone addiction [6,9]. in studies from the USA [7] and Korea [8]. The physical health of students was shown to be negatively impacted by excessive smartphone use.

In a systemic review In 6 studies, a relationship was discovered between the amount of time spent using a smartphone and musculoskeletal complaints including shoulder and neck pain [10].

In another study at Umm Alqura university including 545 participants, 61.3% of them experienced neck pain, 49.5% hand pain and 36.1% shoulder pain [6]. These findings are in line with the last-mentioned study that showed smartphone users frequently experience discomfort in their necks, shoulders, and other body regions, and that usage time closely correlates with the degree of those symptoms.

One of the factors that increases the risk of neck pain and disability is repeated and prolonged neck flexion [22,23] consequently to frequent and recurrent neck flexion posture, the natural angle of cervical spine will be affected as well as that the stress to cervical spine will be increased [24], loss of proprioception in cervical vertebra [25], also causes muscles and ligaments to spasm [26].

People who use their smartphones frequently may be more prone to thumb pain. A recently released study revealed that smartphones that encouraged the use of just the thumb or just one finger when texting were linked to a high prevalence of musculoskeletal disorders [27].

Smartphone users and non-users both had significantly larger flexor pollicis longus tendons on their dominant sides compared to non-dominant sides, but the high smartphone users had the most differences [28]. According to kim and koo pain and fatigue worsened with longer smartphone use. Mostly noted in the left cervical erector spinae and the left and right upper trapezius muscles with no differences or changes in contralateral side [28].

When asked about cases in which such symptoms were thought to be related to the usage of the device, the cervical region was mentioned the most (43.87% of the cases discussed). It was also found that those who type on their phones with the head at 45° and 60° angles are about twice as likely to have higher scores of severe symptoms than those typing with their neck at 0° (anatomical position) [29].

Study limitations

It is critical to be aware of the study's limitations when evaluating the findings. First, our study had a small number of participants, and second, the participants were all female. Third, the measurement was done in a single setting, which may not be sufficient to determine the effect of smartphone usage on neck angle. Overall, it is suggested that future research consider neck pain, and muscle activity by using electromyography, and neck flexion angle while using a smartphone. This should contribute to a better understanding of the effects of smartphone use on the musculoskeletal system.

CONCLUSION

The results showed that both posture and usage time had statistically significant effects on neck flexion angle. Additionally, the neck flexion angle significantly decreased in sitting postures compared to standing postures and increased significantly over time in all postures.

Availability of data and materials

The data sets generated and analyzed during the current study are available on request due to privacy/ethical restrictions.

Declaration of interest statement

The authors declare that they have no competing interests.

Compliance with ethical standards

All procedures performed in study were in accordance with the ethical standards of the institutional and/or national research committee.

Funding/Support and role of the sponsor

None

Conflict of Interest

The authors declare that they have no conflicts of interest.

Informed consent

All participants signed an informed consent form before engaging in the study.

Author contributions

All authors contribute in concept and design of the study, Acquisition of data and data analysis, critical revision of the manuscript and final approval of the version to be submitted

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