The effect of smartphone use on neck flexion angle and hand grip power among adolescents: Cross-sectional study

TAMER M. SHOUSHA[1,2], HAMADA AHMED HAMADA[3] ✉, NEHAD A. ABO-ZAID[4], MOHAMED Y. ABDELHAMID ABDELSAMEE[5], MOHAMED A. BEHIRY[6]

[1]Department of Physiotherapy, CHS, University of Sharjah, United Arab Emirates
[2]Department of Physical Therapy for Musculoskeletal Disorders and its Surgery, Faculty of Physical Therapy, Cairo University, Egypt
[3]Department of Biomechanics, Faculty of Physical Therapy, Cairo University, Egypt
[4]Department of Physical Therapy for Paediatrics, Faculty of Physical Therapy, South Valley University, Qena, Egypt
[5]Department of Basic Science, Faculty of Physical Therapy, Delta University for Science and Technology, Egypt
[6]Department of Orthopaedics, Faculty of Physical Therapy, Delta University for Science and Technology, Egypt

ABSTRACT

Background: The use of smart phones has become increasingly popular and almost indispensable in contemporary life, but many studies have addressed that excessive use negatively affects the various developmental domains. Purpose: The purpose of this study was to examine the effect of prolonged smartphone use on the forward neck translation, neck flexion angle and handgrip power for duration of 8 weeks. Materials and Methods: Ninety students from nine different international schools in Sharjah, UAE, with age ranging between 13-17 years. Participated in this study. Subjects were divided into two groups based on their daily frequency of smartphone use. Group (I) using smart phones less than 4 hours/day and Group (II) using more than 4 hours/day. The Neck flexion angle and forward neck translation were measured by the posture assessment mobile application (PostureCo, Inc), during their normal straight upright postural standing position. Handgrip power was measured with a Handheld Dynamometer (HHD) for both dominant and non-dominant hands, with arms abducted 30 degrees and wrist slightly extended (10 degrees). Measures were repeated 3 times and the average was considered for data analysis. Results: After 8 weeks of smart phone usage, statistical analyses revealed significant increase and decrease in the forward neck translation and neck flexion angles respectively. On the other hand, there were no statistically significant differences in handgrip power in both groups. Conclusion: Our results revealed the significant effect of the prolonged use of smartphones on the neck flexion angle, forward head translation without affecting handgrip power.
Keywords: Smart phone; Neck flexion angle; Forward head translation; Hand grip power.

✉ **Corresponding author.** *Department of Biomechanics, Faculty of Physical Therapy, Cairo University, Egypt.*
E-mail: hamada.ahmed@pt.cu.edu.eg

INTRODUCTION

Adolescents spend prolonged time using their smartphones due to frequent visiting of social media sites (Attila, 2015), so they are more susceptible to negative effects of smartphone use due to their receptive and easily adaptiveness to new technologies. In addition, they are highly sensitive to the effect of their peers and environment (Jo, Na & Kim, 2017). Twenty-six percent of adolescents support spending more than 8 hours / day using screen media (Domoff et al., 2019). The incidence of problems in adolescence with overuse smartphone ranged from 5% (Lopez-Fernandez, 2015) up to 50% (Yen, et al., 2009) with a higher incidence in younger adolescents than older adolescents (Lopez-Fernandez, 2014). The use of smartphones has been gradually increasing throughout the years due to a variety of factors. Some of which are the different brands of smartphones with attracting capabilities, as well as to the various social media applications. Moreover, game applications get people addicted to their phones without being aware of the consequences their body and posture deformities, as well as psychosocial problems (Arslan, 2013). This may predispose to musculoskeletal abnormalities including forward neck posture, hyper lordosis and increased neck and upper extremity pain (Lee, 2015).

The adolescents are also vulnerable to smartphone addiction (Jo, Na & Kim, 2017). This addiction resulting from overuse has negative impact on their emotions, behaviours, social communications, academic achievement, and conflicts with family members (Attila, 2015). As the adolescence is a critical duration for brain development, the overuse of smartphones in this period has inhibitory effects on functional connectivity in the anterior insula and the primary motor cortex (Kim, Kim, & Pyeon, 2016).

A new medical term '*Text Neck*' is now applied to the harmful and dangerous condition resulting from extensive and long-term use of mobile phones (Neupane, Ifthikar & Mathew, 2017). This condition is known to be affecting majority of mobile phone users and is also considered as an amplifying sharp global burden, affecting population of both sex and all the age groups belonging to every society (Samani et al., 2018).

The excessive use of smartphones eventually produces considerable stress on the cervical spine and therefore cause neck pain (Kim & Kim, 2015). Individuals who are constantly using their smartphones may experience a dramatic decrease in the amount of time they can spare for other social relations, especially activities that involve face to face interactions (Lee et al., 2015). Moreover, it can lead to somatic psychosocial problems reported include complaints such as anxiety, insomnia, depression, psychological distress, and unhealthy lifestyle (Seong-Soo & Bo-Kyung, 2018).

On the other hand, poor posture while looking at the visual display terminals of smartphones for extended periods causes musculoskeletal problems (Kim & Kim, 2015; Lee, 2015; Seong-Soo, & Bo-Kyung, 2018). Visual display terminals of a tablet or cell phone have smaller screens than that of a regular desktop computer, requiring the users to bend his/her neck more, thereby increasing the activity of the neck and shoulder muscles.

The angle at which someone looks at a visual display terminal with a small screen is significantly lower than that of a big screen (Lee, 2016). The average cervical flexion angle is 38.5 degrees when watching a digital multimedia broadcasting phone, and this cervical flexion posture increases the muscle activity of the upper trapezius and splenius capitis muscles compared to a cervical neutral position (Yoo, 2008).

Other side effects of smartphone overuse include enlargement of the median nerve, causing pain in the thumb, decreasing pinch strength and hand function, and significantly higher median nerve cross sectional

areas were observed in the dominant hands of the high smartphone users than in the non-dominant hands (İNal, 2015).

On the other hand, it was reported that there was no difference in the hand muscles' fatigue levels between both genders, and it was recommended that further research studies need to compare between using different brands of mobiles to understand the appropriateness of the design of the phone itself (Sharan & Ajeesh, 2012).

As previous studies focused on the musculoskeletal hazards of smart phone use but did not consider the longevity of usage, therefore the purpose of this study was to measure the effect of prolonged smartphone use on neck flexion angle and hand grip power. We hypothesized that prolonged smartphone use will have an effect on the forward neck translation, the neck flexion angle and hand grip power after a duration of 8 weeks.

MATERIALS AND METHODS

Study design
A cross-sectional study was conducted on adolescent students during the period from March 2020 to January 2021. Informed consents were signed by the parent or guardian of each participant. Verbal assent was obtained from each participant in the presence of the parent or legal guardian as well. Procedures of our study had No: REC-18-02-26-02-S approved by the Institutional Ethical Committee Clearance of University of Sharjah, and also it was registered on Clinicaltrial.gov and the registration number was NCT04715009 that was registered on Clinicaltrial.gov.
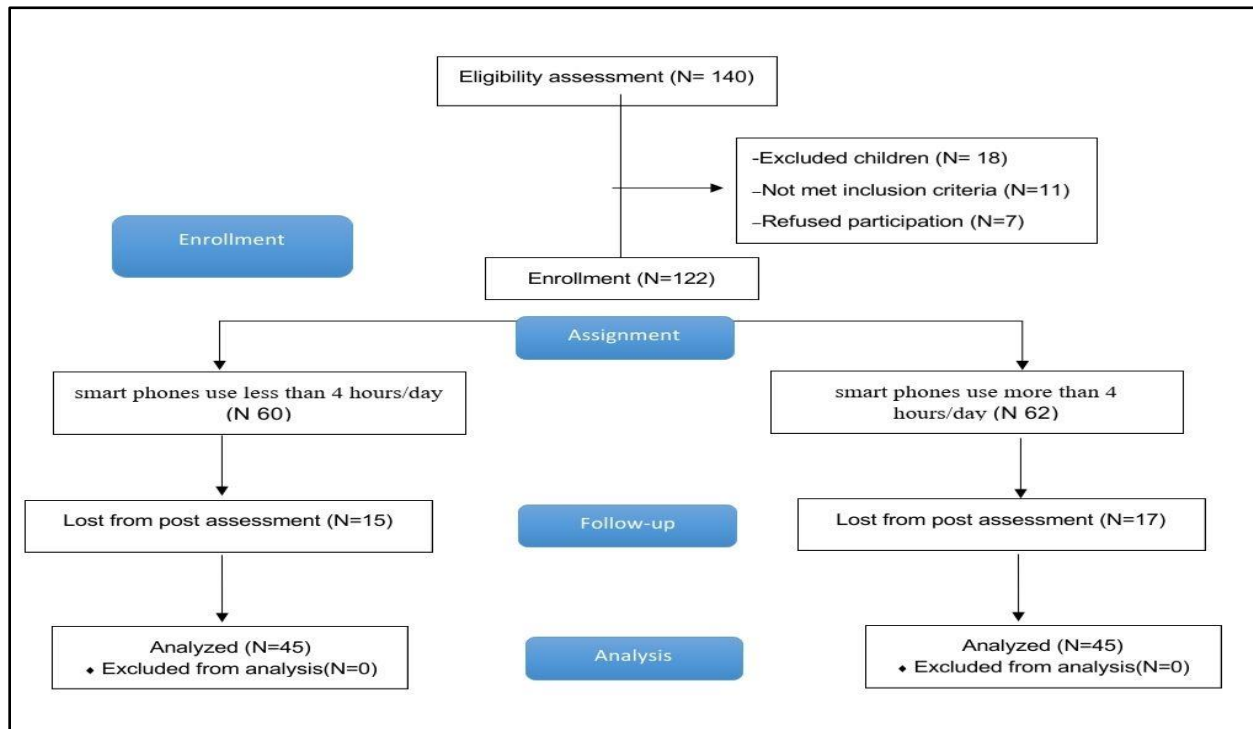

Figure 1. Flowchart of the study.

Study population

A convenient sample of ninety male and female students from 9 different international schools between 13 to 17 years of age were recruited for this study. Participants were free from any musculoskeletal or neurological pathologies. They all reported the use of smartphones with nearly the same dimensions and weight including iPhone 8 plus, [158.4 mm in height and 78.1 in width] and Samsung note 6-7 [153mm in height, and 74.5mm in width]. Participants were excluded if they suffered from any previous or current neurologic problems, spinal deformities or had a history of neck, or upper extremity surgery.

The participants were divided into two groups based on using their mobile phone for either more than or less than 4 hours every day (Samaan et al., 2018) (flowchart Figure 1). This information was obtained as the participants filled a Smartphone Usage questionnaire (Appendix 1). The assessment was performed by an experienced physical therapist at base line and after 8 weeks.

Outcome measures

With regards to the hand grip Power, participants were asked to stand upright having their arms 30^0 abducted and wrist 10^0 extended, holding the dynamometer and gripping it with their most strength upon full exhalation. Measurement was repeated three times and the average was taken for both the dominant and non-dominant hands (Levangie & Norkin, 2005). Next, participants stood with their backs to the wall. They were asked to stand straight according to their normal relaxed forward-facing position. The posture assessment mobile application was used to measure the neck flexion angle and forward neck translation (Lee, Lee, & Park, 2015) (fig 2). The higher the neck flexion angle, the more neutral the head position is, the lower the neck flexion angle the more the subject has a relaxed non-neutral position (Hansraj, 2014). These measurements were taken on two successive occasions, at baseline and at the end of 8 weeks' time.
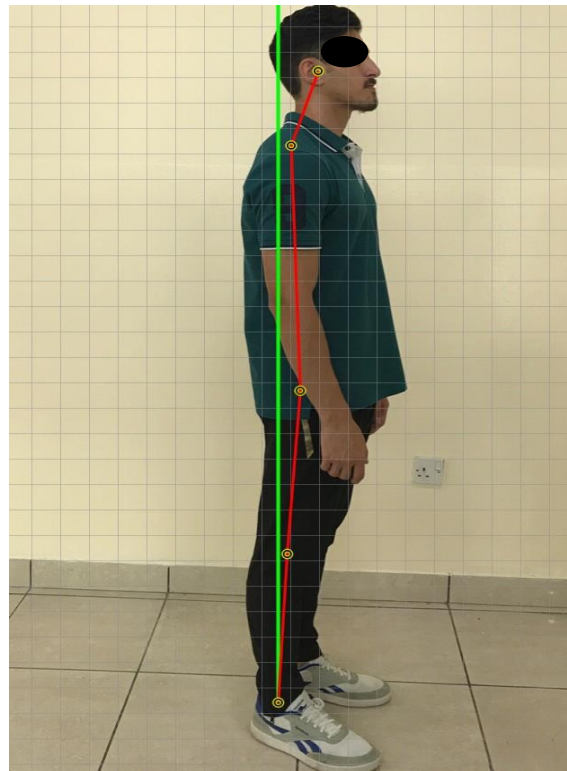

Figure 2. The posture assessment mobile application.

RESULTS

Statistical power analysis

The sample size for this study was calculated using the G*power program 3.1.9 (G power program version 3.1, Heinrich-Heine-University, Düsseldorf, Germany). Sample size calculation based on F tests (ANOVA: Fixed effects, omnibus, one-way), Type I error (α) = .05, power (1-α error probability) = .80, and effect size f (V) = 0.260 with 2 independent groups comparison for 4 major variable outcomes. The appropriate minimum sample size for this study was 120 patients (60 patients in each group as a minimum).

The SPSS for windows version 22 was used to analyse the data. One-way ANOVA test was used to assess differences within and between groups regarding forward head translation, neck flexion angle and hand grip power. As presented in Table 1, there was no significant difference (p > .05) between groups with regards to age, weight, height, gender distribution or hand dominance.

Table 1. General characteristics of the two studied groups.

	Group A (n = 45)	Group B (n = 45)		p-value
Age (years.)	15.13 ± 1.01	16.47 ± 0.68		.120 (NS)
Weight (kg.)	54.64 ± 2.43	57.25 ± 1.1		.231 (NS)
Height (cm)	165.30 ± 6.82	166.14 ± 7.65		.161 (NS)
Gender				
Male	22 (73.3%)	20 (66.7%)	$\chi^2 = 0.317$	.563 (NS)
Female	8 (26.7%)	10 (33.3%)		
Dominance				
Right	21(70.0%)	9 (30%)	$\chi^2 = 0.218$	.641 (NS)
Left	7(23.33%)	23 (76.66%)		

Data are expressed as mean ± SD or number (%). χ^2 = Chi square test. NS = p > .05 = not significant.

As presented in Table 2, there was a significant difference (p < .05) between groups regarding usage hours per day.

Table 2. Comparison between values of average time of smartphone use in the two studied groups.

Duration of smartphone use/day (hrs.)	Group A (n = 30)	Group B (n = 30)	Z value	p-value
	6.37 ± 0.98	3.62 ± 2.26	-6.413	.001*

Data are expressed as mean ± SD. Z value = Mann-Whitney test, * Significant p < .05.

Results did not reveal any statistical difference for the hand power of both sides as shown in table (3). On the other hand, regarding forward head translation, within group comparisons showed a statistically significant difference for both groups post 8 weeks of smartphone use represented as p = .001 and p = .003 respectively. Similarly, between groups comparisons revealed a statistically significant difference post 8 weeks of smartphone represented as p = .001 (Table 3).

Regarding neck flexion angle, within group comparisons showed a statistically significant difference for both groups post 8 weeks of smartphone use represented as p = .001 and p = .001 respectively. Similarly, between

groups comparisons revealed a statistically significant difference post 8 weeks of smartphone represented as p = .041 (Table 3).

Table 3. ANOVA analysis for hand power, forward neck translation and neck flexion angle in both groups at baseline and post 8 weeks of smart phone use.

Dependent Variable		Group A (Mean ± SD)	Group B (Mean ± SD)	*p*-value
Right Hand power	Base line	34.4 ± 4.3	31.6 ± 6.1	.681
	Post 8 weeks	35.7 ±5.2	32.1±7.4	.543
	p-value	.548	.510	
Left Hand power	Base line	30.6± 8.1	32.8± 6.1	.716
	Post 8 weeks	31.4± 6.1	34.8± 2.1	.680
	p-value	.811	.698	
Forward neck translation	Base line	5.9 ±1.6	5.1 ±1.5	.033*
	Post 8 weeks	7.2 ±2.6	6.4 ±1.4	.001*
	p-value	.001*	.003*	
Neck flexion angle	Base line	61.4 ±4.6	66.9 ±6.6	.027*
	Post 8 weeks	56.1 ±7.8	59.6 ±5.6	.041*
	p-value	.001*	.001*	

* Significant p < .05.

DISCUSSIONS AND CONCLUSIONS

The purpose of this study was to examine the effect of prolonged smartphone use on forward neck translation, neck flexion angle and handgrip power after duration of 8 weeks.

Smart phone is one of the fastest growing technological developments of all times and becoming an integral part of daily life among adolescents. Frequent use of smartphones forces the users to adopt an awkward posture to increased risk of musculoskeletal problems.

The use of smartphones in an incorrect manner and wrong postural alignment usually causes neck pain, back pain, and other musculoskeletal issues (Lee, 2015). In this study, the participants used their phone for either more than or less than 4 hours every day. The handgrip power, neck flexion angle and forward head translation were assessed at baseline and after 8 weeks. After 8 weeks of smart phone usage, statistical analysis revealed significant increase and decrease in the forward neck translation and neck flexion angles respectively without affecting handgrip power.

Our findings suggest that smartphones have a direct effect on the flexion angle of the cervical spine and the forward head posture. This came in agreement with several studies revealing significant musculoskeletal defects and increased musculoskeletal activity rates which could cause fatigue on the longer term (Yoo, 2008; Sharan & Ajeesh, 2012; Lee, Lee, & Park, 2015; Lee, 2016). In addition, some have even shown neurological deficits, and enlarged median nerve accompanied by hand pain (İNal, Demİrcİ, Çetİntürk, Akgönül & Savaş, 2015).

Janwantanakul, Sitthipornvorakul & Paksaichol, 2012 & Hansraj, 2014 concluded that, loss of normal curvatures of the spine were resulting from increasing the bending of the head in forward position at varying degrees which leads to substantial increase of stress towards the cervical spine.

The finding of the study supports the findings of Hakala et al. 2006 who confirmed that prolonged smartphone use increases the risk of neck–shoulder pain in adolescents, as well as Kim, Kim & Pyeon, 2015, reporting that frequent smartphone use provides neck and shoulder discomfort.

Our results clearly point to the fact that consequences of smart phone use including increased forward neck translation and decreased neck flexion angle may be strongly correlated with other disorders directly affected by the head and neck position as tension type headaches (Sharan & Ajeesh, 2012).

Limitations
The sample size was limited based on the current Covid-19 pandemic and related social distancing and restrictions. Also, the duration of usage was assumed based on the subjective responses of the participants without any means to control the time of usage.

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APPENDIX 1. Smartphone Usage questionnaire.

SMART PHONE USAGE AND NECK FLEXION ANGLE WITH HAND GRIP

Thank you for taking the time to participate in this survey

Statement					
History of neck pain					
How often you experienced neck pain last 6 months?	Not at all	Once	Monthly	Weekly	daily
Rate the average intensity of neck pain last 6 months	Very mild	Mild	Moderate	Severe	Very severe
Have you been seen by a Chiropractor last 6 months for neck pain?	Yes			No	
If yes specify the number of visit last 6 months	_____				
Have you taken pain killers last 6 months for neck pain	Yes			No	
Have you done cervical surgery? If yes, what year?	Yes, Year: _____			No	
Do you have arthritis (joint inflammation) of neck or spin?	Yes			No	
Smart Phone Usage					
What type of smartphone you use?	iPhone	Samsung	Motorola	Other: _____	
How much time you operate your phone daily?	0-30 min	>30min - 1 hour	>1-2 hours	>2-4 hours	>4 hours
What is the most common use for your smartphone?	Call	Texting	Reading (article or e-book)	E-mail	Social Media
	Playing Games	Watching Videos	Capture Photos or Videos		Listening to audio hands free
What is the second most common use for your smartphone?	Call	Texting	Reading (article or e-book)	E-mail	Social Media
	Playing Games	Watching Videos	Capture Photos or Videos		Listening to audio hands free
What is the third most common use for your smartphone?	Call	Texting	Reading (article or e-book)	E-mail	Social Media
	Playing Games	Watching Videos	Capture Photos or Videos		Listening to audio hands free