



Effect of prolonged smartphone use on cervical spine and hand grip strength in adolescence

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Abstract

Background: smartphones have become a necessity for most children as they are used for communication and entertainment purposes. They spend most of their time in using smartphones. This could have side effects on their health.

Purpose: to assess the effect of prolonged smartphones use on cervical spine, hand grip strength, median and ulnar nerves conduction velocities of the forearm in adolescent children who use it more than four hours per day.

Methods: 60 normal subjects with ages ranging from 14 to 18 years were divided randomly into two groups of equal number (group A, group B): group A represent the control group who use smartphones less than four hours per day. Group B represent the study group who uses smartphone more than four hours per day. Electromyography machine was used to investigate nerve conduction velocity of ulnar and median nerves. Universal goniometer was used to measure forward head angle. Visual Analogue Scale was used to assess the neck pain. Hand dynamometer was used to measure hand grip strength for subjects of both groups.

Results: showed significant differences in conduction velocity of ulnar nerve, forward head angle and visual analog scale for pain, indicating the effect on group B, while showed no significant difference in conduction velocity of median nerve and hand grip strength between the two groups.

Conclusion: Prolonged use of smartphones in adolescence decrease conduction velocity of ulnar nerve, leading to increased forward head position angle and neck pain, without effecting on handgrip strength and conduction velocity of median nerve.

Keywords: smartphone, cervical spine, hand grip Strength, adolescence

Introduction

Smartphones have become a necessity for most children, they are used for both communication and entertainment purposes such as; messages, music, media, internet access, photos and games (Arslan, 2013) [1].

While using a smartphone, children usually flex their neck downwards to stare at the lowered object (smartphone) and maintain the head in a forward position for long periods of time, which may cause musculoskeletal disorders (Park *et al.*, 2015) [2].

Forward head posture (FHP) is the most common side effect of prolonged, sustained mobile or tablet use. This leads to extension at atlanto – occipital (C1 to C2) joints with flexion of lower cervical spine (C4 to C7) and flattening of mid cervical lordosis which causes joint dysfunction, abnormal afferent information affecting the tonic neck reflex and encourages the gradual adaptation of FHP (Fernandez *et al.*, 2010) [3].

Extensive use of smartphones can be associated with physical health-related problems, such as pain in the wrists and neck, and it also exposes hands to intense stresses that may lead to pain and musculoskeletal disorders of the hand and thumb (Jonsson *et al.*, 2011) [4].

Sixty well developed adolescents of both genders participated in this study after signing institutionally approved consent form prior to data collection. They were recruited from Faculty of Physical Therapy students at Cairo University and secondary schools. Their ages ranged from 14 to 18 years. They were subdivided randomly into two groups of equal number 30 subjects each (A, B).

Design of the study

Cross sectional design was applied in this study. 60 subjects were grouped into two groups A, B:

- **Control group A:** consisted of 21 females and 9 males who weren't exposed to prolonged use of smartphone (less than 4 hours per day).
- **Study group B:** consisted of 20 females and 10 males who are using smartphone for a prolonged time (more than 4 hours per day and starting using it at least 4 years ago to detect the real effect of smartphone use) (Brattberg, 2002) [5].

Inclusion criteria

1. Subjects of late childhood (adolescence).
2. Age of participant ranged from 14 to 18 years.
3. Subjects with normal development.

Exclusion criteria

Subjects, instrumentation and procedures

1. Athletic one.
2. Genetic spinal deformity.
3. Injury to the neck or upper extremity.
4. History of inflammatory joint disease.
5. History of surgical intervention at the neck or upper extremity.
6. Patients with neuropaediatric problems.

Instrumentation for assessment

1. **Hand Grip Dynamometer:** It was used for measuring the maximum isometric strength of the hand muscles in kilograms. It is a simple and commonly used test of general strength level (Levangie and Norkin, 2005) [6].
2. **Computerized Electromyography (EMG):** Computerized four channel EMG Tonnie's neuroscreen plus 1.59 was used to test the median, ulnar nerves conduction velocity and to record the latency and amplitude of the median, ulnar nerves motor fibers in children using mobile phones more than 4 hours per day and non-users or using mobile less than 4 hours per day.
3. **Universal goniometer:** Goniometry refers to the measurement of angles, in particular the measurement of angles created at human joints by the bones of the body.

The examiner obtains these measurements by placing the parts of the measuring instrument, called a goniometer, along the bones immediately proximal and distal to the joint being evaluated. Goniometry may be used to determine both a particular joint position and the total amount of motion available at a joint (Norkin and White, 2009) [7].

4. **Visual analogue scale (VAS):** It was used to measure the intensity of neck pain after prolonged use of smartphone and assess pain in non-users group. It was a vertical or horizontal 10 cm line graduated by different levels of pain, starting from 0 (no pain) till 10 (worst pain) (Swartzberg, 2002) [8].

Results

The main purpose of this study was to investigate the effect of prolonged smartphone use on cervical spine and handgrip strength.

It was intended to collect the measurements data of median and ulnar nerves conduction velocity by EMG machine, angle of forward head position by universal goniometer, handgrip strength by hand dynamometer device and pain assessment by VAS in both groups (A and B).

1. General characteristics of the patients

Table 1: General characteristics of the two studied groups

	Group A (n= 30)	Group B (n= 30)	t value	P value
Age (yrs.)	17.13 ± 1.01	17.47 ± 0.68	-1.501	0.139 (NS)
Weight (kg.)	72.73 ± 2.36	70.25 ± 13.58	0.741	0.462 (NS)
Height (cm)	164.30 ± 8.84	167.17 ± 6.75	-1.412	0.163 (NS)
Gender				
Girl	22 (73.3%)	20 (66.7%)	$\chi^2= 0.317$	0.573 (NS)
Boy	8 (26.7%)	10 (33.3%)		
Dominant hand				
Left	3 (10.0%)	2 (6.7%)	$\chi^2= 0.218$	0.640 (NS)
Right	27 (90.0%)	28 (93.3%)		

Data are expressed as mean ± SD or number (%). χ^2 = Chi square test. NS= p> 0.05= not significant.

2. Duration of smartphone use

Table 2: Comparison between values of onset of smartphone use in the two studied groups

	Group A (n= 30)	Group B (n= 30)	Z value	P value
Onset of smartphone use (yrs.)	2.67 ± 1.40	8.68 ± 2.11	-6.550	0.001 (S)
Duration of smartphone use/day (hrs.)	2.07 ± 0.98	6.62 ± 2.26	-6.413	0.001 (S)

Data are expressed as mean ± SD. Z value= Mann-Whitney test. S= p< 0.05= significant.

3. Pain scale and FHPA

Table 3: Comparison between values of pain scale and FHPA in the two studied groups

	Group A (n= 30)	Group B (n= 30)	Z value	P value
Pain scale	1.70 ± 0.99	6.13 ± 1.66	-6.318	0.001 (S)
FHPA	61.17 ± 5.83	52.50 ± 2.54	5.274	0.001 (S)

Data are expressed as mean ± SD. Z value= Mann-Whitney U S= p<

0.05= significant.

4. Hand dynamometer

Table 4: Comparison between values of hand dynamometer in the two studied groups measured in the right and left hands.

	Group A (n= 30)	Group B (n= 30)	Z value	P value
Right hand	56.07 ± 20.49	53.67 ± 13.89	-0.022	0.982 (NS)
Left hand	52.07 ± 19.62	45.83 ± 14.80	-1.103	0.270 (NS)

Data are expressed as mean ± SD. Z value= Mann-Whitney test. NS= p> 0.05= not significant.

5. Nerve conduction velocity measured at right and left median nerves

Table 5: Comparison between mean values of nerve conduction velocity in the two studied groups measured at right and left median nerves.

	Group A (n= 30)	Group B (n= 30)	t value	P value
Right	66.63 ± 7.26	66.26 ± 8.06	0.185	0.854 (NS)

Left	66.03 ± 6.27	68.93 ± 7.44	-1.633	0.108 (NS)
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Data are expressed as mean ± SD. NS= p> 0.05= not significant.

6. Nerve conduction velocity measured at right and left ulnar nerve

Table 6: Comparison between mean values of nerve conduction velocity in the two studied groups measured at right and left ulnar nerves.

	Group A (n= 30)	Group B (n= 30)	t value	P value
Right	64.94 ± 5.08	55.98 ± 8.06	5.149	0.001 (S)
Left	63.07 ± 5.67	57.75 ± 7.68	3.053	0.003 (S)

Data are expressed as mean ± SD. S= p< 0.05= significant.

7. Right and left median nerves within each group

Table 7: Comparison between mean values of right and left median nerves in each of the two studied groups.

	Group A (n= 30)	Group B (n= 30)
Right	66.63 ± 7.26	66.26 ± 8.06
Left	66.03 ± 6.27	68.93 ± 7.44
t value	0.341	-1.334
P value	0.735 (NS)	0.187 (NS)

Data are expressed as mean ± SD. NS= p> 0.05= not significant. Right and left ulnar nerves within each group

Table 8: Comparison between mean values of right and left ulnar nerves in the two studied groups.

	Group A (n= 30)	Group B (n= 30)
Right	64.94 ± 5.08	55.98 ± 8.06
Left	63.07 ± 5.67	57.75 ± 7.68
t value	1.343	-0.871
P value	0.184 (NS)	0.387 (NS)

Data are expressed as mean ± SD. NS= p> 0.05= not significant.

Discussion

The aim of this study was to investigate the effect of prolonged smartphone use on cervical spine and handgrip strength in adolescence.

Sixty healthy subjects from both genders participated in this study and were subdivided into two groups of equal number, group (A) included 30 subjects that were non-users of smartphones and group (B) included 30 users of smartphones who are exposed to them more than four hours per day for more than 4 years. Ming *et al.*, (2006) [9] and Gyu *et al.*, (2012) [10] found that upper extremity musculoskeletal system symptoms appeared in adults who used smartphones for long periods of time exceeding three years.

The results of our study showed that there is no significant difference between group (A) and group (B) as regard to age, gender, weight, height and dominant hand. Both groups were comparable for age and sex distribution to ensure the complete randomization and reduce all factors that might bias the results as much as possible.

As regard to pain, neck pain was assessed by VAS that is which a reliable and valid scale for assessment of chronic pain (Langley and Sheppard, 1985 and Mark *et al.*, 1998). Our study showed that there was a highly significant difference between group (A) and group (B) which was higher in group (B). This result supports the fact that smartphone users suffer

from chronic neck pain due to prolonged static position of neck in flexion angle during smartphone use. This is confirmed by many previous studies such as; Ackland *et al.*, (2011) [13], Alzarea and Patil (2015) [14], Sunil *et al.*, (2017) [15] and Ayushi and Mugdha (2018) [16] who concluded that flexed neck most commonly causes neck pain and soreness. Text neck syndrome is a modern age term that describes repeated stress injury and pain in the neck resulting from excessive watching or texting on smartphone over sustained periods of time (Neupane *et al.*, 2017) [17]. In addition, looking down at your smart phone too much can lead to upper back pain ranging from chronic, nagging pain to sharp and severe upper back muscles spasm.

Smartphone use encourages incorrect postures like neck bending or hunched postures (Hansraj, 2014) [18]. This causes an increase in the weight supported by the cervical spine as the head is flexed. Thus, habitual postures cause cervical extensors to weaken, resulting in atrophy due to chronic tightness and spasm which squeezes out oxygen and nutrient rich blood thus starving the muscle. This spasm and tightness of neck muscles invariably cause quite a lot of pain. (Ayushi and Mugdha, 2018) [16].

Continuous use of smartphones can cause repetitive microtrauma to the musculoskeletal structures giving rise to pain. This repetitive microtrauma is caused by alteration of length-tension relationship in the neck muscles. Also, in individuals performing repetitive tasks such as using smartphones may be associated with overload of low threshold motor units (Mork and Westgaard, 2006) [19].

Neck pain in turn can affect the cervical proprioception which is defined as a special type of sensation that informs the brain about sensations of deep organs and relationships between muscles, joints and generates afferent information that is crucial to effective and safe performance of motor tasks (Stillman, 2002) [20]. Due to the pain, there is change in the muscle fiber types, which reduces endurance of the cervical muscles specially the craniocervical flexors (O'Leary *et al.*, 2007) [21]. Furthermore, due to altered muscle function and altered length-tension relationship, there is compromise of cervical spine stability which increases the motion and mechanical load of the cervical segments (Falla *et al.*, 2004) [22]. Abnormal loading, decreased endurance, fatigue and pain contribute to a significant deficit in feed forward control of the cervical spine. These could be contributing factors which can make the cervical spine more prone to strain. Thus, reporting of significant pain by smartphone users is an alarming factor which could be a precursor to neuromotor dysfunction (Ayushi and Mugdha, 2018) [16].

In our study, the mean values of measurements of forward head angle (FHA) in groups (A) and (B) was found to be highly significant. That explained that smartphone users (group B) had forward head position due to looking downwards or to hold their arms out in front of them to read the screen, which makes the head move forward and causes an excessive anterior curve in the lower cervical vertebrae and an excessive posterior curve in the upper thoracic vertebrae to maintain balance. Thus, placing stress on the cervical spine and neck muscles which lead to forward head position.

This was also confirmed by Park *et al.* who said that forward-head posture is observed while using a smartphone for longer

duration which may cause upper crossed syndrome and its related symptoms.

Forward head posture is defined as a posture that adopts upper cervical extension and lower cervical flexion. The center of gravity of the head in this posture is positioned at the front rather than the vertebral body weight. This increase in forward head posture has been demonstrated to correlate with respiratory muscle weakness in patients who have neck trouble, and accordingly led to muscle weakness and a decrease in the range of motion (Kapreli *et al.*, 2009; Yong-Soo *et al.*, 2017) ^[23, 24].

In addition, forward head posture usually leads to increased stress due to the muscle shortening of the neck extensors, especially at the back of the head. Thus, this problem can be addressed through an improvement of the forward head posture, for example, muscle strengthening for posture alignment or stretching for shortened muscles (Kendall *et al.*, 2005; Siao *et al.*, 2017) ^[25, 26].

Gravitational demands on the neck muscles are reported to be 3–5 times higher when holding a handheld device with a flexed head and neck posture than with a seated neutral posture (Vasavada *et al.*, 2015) ^[27].

Yan *et al.* revealed that smartphone use was correlated with a more static and more flexed spinal posture compared with desktop computer typing. He compared two methods of text entry on a smartphone: bilateral texting was associated with an increased cervical flexion while unilateral texting was associated with an asymmetric cervical posture. This indicates both text-entry methods on a smartphone are non-favorable as both of them were associated with a non-neutral posture of the cervical spine.

Young *et al.* and Deepika *et al.* have demonstrated that forward head posture causes spinal deformation, which increases scapula deformation, lordosis of the cervical vertebra, and kyphosis of the upper thoracic vertebra. They have also shown that such deformation causes neck pain and contracture of the muscles around the shoulders.

The current study found that there is a significant difference between the right and left ulnar nerve conduction velocity in groups (A) and (B). The users group were less than non-users in ulnar nerve conduction velocity but still within lower limit of normal level (55m/s) (Shan *et al.*, 2016) ^[31]. This demonstrated that prolonged use of smartphone affects the ulnar nerve conduction velocity due to sustained neck flexion due to looking downward at the smartphone screen. This effect on the ulnar nerve conduction velocity occurred because the ulnar nerve is derived from the medial cord of brachial plexus and contains fibers from spinal roots C8 and T1 which were compressed by prolonged static flexion during smartphone use.

Unfortunately, there were no previous studies till now about the effect of prolonged smartphone use on nerve conduction velocity of ulnar nerve.

The results of the statistical analysis in this study revealed that there were no significant differences between the two groups in the handgrip strength and the conduction velocity of the median nerve.

The effect on the ulnar nerve with the preservation of median nerve could be explained by the origin of both nerves. The origin of ulnar nerve comes from C8, T1 nerve roots which

are completely compressed by neck flexion while the origin of median nerve comes from C5, C6, C8, and T1 which are not completely compressed by the neck flexion.

According to our study, the strength of handgrip was not affected by prolonged neck flexion at this age but we expect that muscles of handgrip especially innervated by ulnar nerve may be affected in old age after many years of smartphone use.

Unfortunately again, there were no previous studies -till now- about the effect of prolonged smartphone use on median nerve and handgrip strength.

Summary

1. There was significant difference in pain scale between the two groups, the group B (smartphone users) had higher pain than group A (non-users) in neck region due to neck muscles spasm because of prolonged use of smartphones.
2. There was significant difference in nerve conduction velocity study of ulnar nerve between the two groups. That group B had lower nerve conduction velocity than group A because of the compression on ulnar nerve due to prolonged neck flexion.
3. There was significant difference in forward head position angle between the two groups, group B had increased angle than group A which means prolonged users of smartphone had forward head position.
4. There was no significant difference in nerve conduction velocity study of median nerve between the two groups, thus the median nerve wasn't affected by prolonged use of smartphone till late childhood age.
5. There was no significant difference in handgrip strength between the two groups, which means that the prolonged use of smartphone didn't affect the handgrip strength in late childhood age.
6. There was no significant difference in nerve conduction velocity study of median and ulnar nerves between right and left side within each group, which means that the compression affection on nerves especially ulnar nerve came from prolonged cervical flexion -proximal- on nerve root not distally on nerve trunk in dominant hand only but affected both hands.

Conclusion

According to the results of this study it can be concluded that prolonged use of smartphone more than four hours per day can affect the cervical region causing forward head position, neck pain due to neck muscles spasm and reduced conduction velocity of ulnar nerve due to prolonged cervical flexion.

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