Effect Of Extensive Use Of Smart Phones On The Functions Of The Upper Extremity

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Abstract

Background: Extensive use of smart phones can be associated with physical health related problems, such as pain in the wrists and neck and exposes hands to intense stresses that may lead to hand and thumb disorders.

Purpose: to investigate the effect of extensive use of smart phones on the functions of the upper extremity, median and ulnar conduction velocity and hand grip strength.

Design of the study: Cross-sectional design.

Methods: one hundred normal subjects with their age ranging from 18 to 25 years were divided into two equal groups. Group A represented the extensive smart phone users for minimum 3-6 hours per day while Group B represented the non-extensive smart phone users for less than 2 hours per day. Electromyography was used for measuring conduction velocities of the median and ulnar nerves, hand dynamometer was used to measure hand grip strength and disabilities of arm, shoulder and hand scale (DASH) was used for assessment of upper extremity function.

Results: The results showed that there were statistical significant decrease in conduction velocity of ulnar nerve at forearm level (p=0.0001) and prolonged motor and sensory distal latencies of median nerve (p=0.0001) in group A while there were no statistical significant differences regarding hand grip strength (p=0.999) and DASH scale (p=0.980).

Conclusion: Extensive usage of smart phones affects conduction velocity of ulnar nerve at forearm and delay sensory and motor distal latencies of median nerve.

Keywords: DASH scale, extensive smartphone use, hand grip strength, nerve conduction velocity.

Introduction

Nowadays mobile technology continues to advance, people often use smart phones instead of computers in their daily life. It is easy to find smart phone users who are walking along the street with their eyes staring at their smart phones and at the same time with their thumb or finger moving on the touch screens. Indeed, smart phone brings us many conveniences.[1]

Modern communication devices such as mobile phones are associated with several painful repetitive stress and nerve compression injuries. Nerves are damaged by repeated use of thumb movements, tingling feelings are caused by the compression of nerves. Increasing evidence shows that prolonged use of a smart phone together with inappropriate wrist position may lead to repetitive strain injury of the wrist especially when fingers, hands and wrists are overused[2]. It also causes physical health–related problems as pain in the neck, hand and thumb disorders.[3]

Nerve conduction velocity “NCV” tests are used to determine the velocity of the electrical signals moving along a specific peripheral nerve. The use of NCV tests permit physicians to distinguish between an injury that aroused in the myelin sheaths or an injury in the nerve axons.[4] It relies on the fiber diameter, de-myelination degree and internodal distance. Motor nerve conduction studies require stimulation of a peripheral nerve while using a recording from a muscle innervated by the nerve. Sensory nerve conduction studies are performed by stimulating a mixed nerve while recording from a mixed or cutaneous nerve.[5]

Motor nerve conduction velocity (MNCV) is performed by electrical stimulation of a peripheral nerve and recording from a muscle supplied by this nerve. Latency is measured in milliseconds (ms) which is the time taken for the electrical impulse to travel from the stimulation site to the recording site.[5]

The disability of the arm, shoulder and hand questionnaire (DASH) is a valid and reliable questionnaire for upper-extremity specific outcome measure that was introduced by the American Academy of Orthopedic Surgeons in collaboration with a number of other organizations. The rationale behind the use of measure for different upper extremity disorders is that it is a functional unit and DASH would be suitable because of its property of being mainly a measure of disability. In addition, facilitates comparisons among different upper-extremity conditions in terms of health burden.[6]

Dynamometer 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 and the most widely used to measure grip strength in the literature.[7,8]

The intent of this research was to establish a valid and applicable foundation of scientific evidence that can be used to make solid decisions about the effect of smart phone extensive use on the functions of the upper extremity.

Subjects, instrumentation and procedures

One hundred participants from both genders participated in this study after signing institutionally approved consent form prior to data collection. Their ages ranged from 18 to 25 years.

Design of the study

Cross sectional design was applied in this study; hundred subjects were divided into two equal groups (A, B), group A represented the extensive smart phone users for minimum 3-6 hours per day while group B represented the non-extensive smart phone users for less than 2 hours per day. The dependent variables were motor and sensory conduction velocity of median and ulnar nerves, motor and sensory distal latencies of median and ulnar nerves, dynamometer and DASH scores, whereas the independent variable was the time in hours of smartphone using per day. One shot measurement was done

Inclusion criteria

One hundred normal subjects with their age ranging from 18 to 25 years 3 and their body mass index between 18.5 and 29.9 kg/m2, all participants were conscious and non-smokers.

Exclusion criteria

The exclusion criteria were as follows: history of diseases in the muscles and nervous system, history of any injuries, fractures or pain in the wrist area, Diabetic patients, history of tobacco or alcohol consumption, hypertension patients, cardiovascular patients, patients with cervical spondylosis, patients with cervical disc prolapsed, patients with thoracic outlet syndrome, pregnant women, hypo thyroidism and carpal tunnel patients.

Procedure:

1- Measuring conduction velocity of the median and ulnar nerves.

EMG, Neuropack S1 MEB-9004 NIHON KODEN, JAPAN was used for Measuring conduction velocity of the median and ulnar nerves.

For median nerve motor conduction velocity:

- The earth electrode was applied around the wrist level .

- The recording motor electrodes was applied , negative electrode on the center of the corresponding abductor pollicis brevis muscle and the positive electrode on tip of thumb or 3 cm distal to the negative electrode.

- The median nerve was stimulated:

A : at wrist level (just above the wrist in the midline).

B:Forearm level (in the cubital fossa just medial to biceps brachii tendon).

C- Axilla.

- The distance between **A to B** & **B to C** was measured by tape measurement & multiplied by 10.

-Nerve conduction velocity was calculated by the following formula:

$$\text{Conduction velocity (Meter/Second)} = \frac{\text{Distance (cm) X 10}}{\text{Proximal latency} - \text{Distal latency}}$$

-Obtained data:

Stimulation site	Data obtained
At wrist	Distal latency
Wrist-Forearm	CV 1 forearm level.
Forearm-Axilla	CV2 Arm level.

For sensory median conduction velocity (antidromic technique):

- The earth electrode was apply around the palm.

- The recording ring electrode was applied

-The negative electrode around the proximal phalanx of index finger.

-The positive electrode distal to the negative one around the distal inter phalangeal joint of index finger.

- The median nerve was stimulated above the wrist at the mid line 14 cm proximal to the negative recording electrode.

-Obtained data only sensory distal latency.

For ulnar nerve motor conduction velocity:

-The earth electrode was applied around the wrist level .

-The recording motor electrodes was applied, negative electrode on the center of the corresponding abductor digiti minimi muscle and the positive electrode on tip of little finger or 3 cm distal to the negative electrode.

- The ulnar nerve was stimulated:

A : at wrist level (just above the wrist on the ulnar border).

B:Elbow level (Above & behind medial epicondyle).

C- Axilla.

-The distance between **A to B** & **B to C** was measured by tape measurement & multiplied by 10.

-Nerve conduction velocity was calculated by the following formula:

$$\text{Conduction velocity (Meter/Second)} = \frac{\text{Distance (cm) X 10}}{\text{Proximal latency – Distal latency}}$$

-Obtained data:

Stimulation site	Data obtained
At wrist	Distal latency
Wrist- Elbow	CV 1 forearm level.
Elbow-Axilla	CV2 Arm level.

For sensory ulnar conduction velocity (antidromic technique):

-The earth electrode was applied around the palm.

- The recording ring electrode was applied:

    -The negative electrode around the proximal phalanx of little finger.

    -The positive electrode distal to the negative one around the distal inter phalangeal joint of little finger.

- The ulnar nerve was stimulated above the wrist on the ulnar border 14 cm proximal to the negative recording electrode.

- Obtained data only sensory distal latency.

2- Measurement of hand grip strength

Hand Grip Dynamometer was used for measuring the maximum isometric strength of the hand muscles in kilograms. The participants positioned their arms based on the American Society of Hand Therapists' recommendations while they were seated with the shoulder adducted and neutrally rotated, the elbow flexed at 90, and the forearm and wrist in a neutral position. Each participant squeezed the handle of the dynamometer as hard as possible and maintained maximal grip contraction. This action was repeated 3 times with 30-second rest periods between trials. The mean score of the 3 trials was calculated. Lower scores indicated reduced grip and pinch strengths.[8]

3- Measurement of upper extremity function.

DASH scale was used for assessment of upper extremity function. The main part of the DASH is a 30-item disability/symptom scale concerning the patient's health status during the preceding week. The items ask about the degree of difficulty in performing different physical activities because of the arm, shoulder, or hand problem (21 items), the severity of each of the symptoms of pain, activity-related pain, tingling, weakness and stiffness (5 items), as well as the problem's impact on social activities, work, sleep, and self-image (4 items). Each item has five response options. The scores for all items are then used to calculate a scale score ranging from 0 (no disability) to 100 (most severe disability). The score for the disability/symptom scale is called the DASH score [9].

Statistical analysis

Statistical analysis was conducted using SPSS for windows, version 23 (SPSS, Inc., Chicago, IL). All parametric results are expressed as means and standard deviations for each group. A two-tailed p level of <0.05 was considered statistically significant. The Kolmogorov–Smirnov test showed that all variables were normally distributed. The independent-samples t test was used to calculate and compare between the variables. Prior to final analysis, data were screened for normality assumption and presence of extreme scores.

Results

The main purpose of this study was to investigate the effect of extensive use of smartphone on the functions of the upper extremity.

1-Demographic data of participants

Table 1: **Demographic data of participants**

	Age	**weight**	**Height**	**BMI**

	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B
Mean ± SD	21.22 ± 1.79	21.2 ± 1.98	69.26 ± 6.4	68.72 ± 6.43	168.44 ± 7.07	168.02 ± 7.51	24.36 ± 0.57	24.29 ± 0.57
Unpaired T value	0.052		0.417		0.285		0.569	
P value	0.958		0.678		0.776		0.570	
Sig.	NS		NS		NS		NS	

NS: no significance

2-Hand dynamometer

Table 2: Hand dynamometer mean values of participants

	Group A	**Group B**
Mean ± SD	35.76 ± 10.28	35.76 ± 14.3
Unpaired T value	-0.002	
P value	0.999	
Sig.	NS	

3- DASH scale.

Table 3: DASH scale mean values of participants

	Group A	**Group B**
Mean ± SD	11.59 ± 1.78	11.6 ± 1.54
Unpaired T value	-0.025	
P value	0.980	
Sig.	NS	

4- Median nerve conduction velocity.

Table 4: Median nerve conduction velocity means values of participants

	Median MCV arm level		**Median MCV forearm level**		**Median Sensory distal latency**		**Median Motor distal latency**	
	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B
Mean ± SD	68.1 ± 2.87	69.1 ± 2.75	57.28 ± 1.82	57.97 ± 1.98	2.33 ± 0.33	2.07 ± 0.27	3.91 ± 0.46	2.75 ± 0.53
Unpaired T value	1.8788		-1.814		4.307		11.526	
P value	0.0632		0.073		0.000		0.000	
Sig.	NS		NS		S		S	

NS: no significance **S : significant**

5-Ulnar nerve conduction velocity.

Table 5: Ulnar nerve conduction velocity means values of participants

	Ulnar MCV arm level		**Ulnar MCV forearm level**		**Ulnar Sensory distal latency**		**Ulnar Motor distal latency**	
	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B
Mean ± SD	62.44 ± 1.97	62.48 ± 1.74	54.33 ± 1.357	59.38 ± 1.468	2.058 ± 0.259	2.04 ± 0.253	2.67 ± 0.41	2.65 ± 0.54
Unpaired T value	-0.116		-17.866		0.355		0.268	
P value	0.908		0.000		0.724		0.789	
Sig.	NS		S		NS		NS	

Discussion

This study aimed to investigate the effect of smart phones extensive use on the functions of the upper extremity. The study was conducted on 100 participants (50 extensive smart phone users and 50 non-extensive smart phone users), motor and sensory conduction velocity of median and ulnar nerves, motor and sensory distal latencies of median and ulnar nerves, dynamometer and DASH scores of the participants were examined and compared to each other.

The results of our study showed that there was no significant difference between both groups as regard to age, gender, weight and height. Also there were no significant difference between both groups as regards to DASH, dynamometer values, median nerve motor conduction velocity, ulnar nerve distal latency and motor conduction velocity at wrist level while there was significant difference between both groups as regards to median nerve motor and sensory distal latencies , ulnar nerve motor conduction velocity in the forearm.

The importance and popularity of smart phones can be understood when we evaluate their sales volume. Now, more than 1.5 billion individuals use smart phones throughout the world. It can be estimated that there will be more than a billion sales of smart phones in 2016. The main reason for this is that smart phones have different applications and their internet access that basic mobile phone do not have.[10]

The smartphone use has been significantly increased in recent years. Furthermore, this increase will continue according to estimations. In a study conducted in 2002, it was observed that the smartphone usage rate was 79%.[11] After just one year, it was indicated in another study that 72% of the individuals who were between the ages of 12 and 19 were using smartphones. Findings showed that the use of smartphone increased in time and its use was prominently high even among young individuals.[12]

Smartphone use encourages incorrect postures like neck bending or hunched postures.[13] 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.[14]

As shown in the present work the extensive use of smart phones had a non-significant result on DASH scores and hand grip strength but had a significant result on median nerve motor and sensory distal latency and ulnar nerve motor conduction velocity in the forearm.

As regard to DASH, there was no significant different between the both groups, this finding can be related to the age of the participants as our subjects were ranged from 18 to 25 years old and in this age it's difficult for them to suffer from shoulder ,arm and hand disabilities especially they were normal subjects.

Our findings were supported by Faik et al., 2018 , who conducted a research to investigate the effect of smart phone usage on the median nerve, they reported that there was no significant relationship between the habit of smart phone use and VAS as well as DASH values of users . [15]

As regard to median nerve**,** there was significant difference between both groups in the motor and sensory distal latencies but there is no significant difference between both groups in motor conduction velocity at forearm and arm levels. These findings can be related to repetitive use of the thumb and hand during smart phone usage that can increase the pressure in the carpal tunnel causing entrapment of median nerve at wrist level.

Our findings were supported by Patel et al., 2017, who conducted a study to investigate nerve conduction velocity of median nerve in mobile phone users, They found that there is a correlation between SNCV and mobile using time. With increased duration of smart phone usage, there is a decrease in sensory nerve conduction velocity. They concluded that there are chances of carpal tunnel syndrome, cumulative trauma disorder, repetitive stress injury in the future for subjects who continue working on mobile phones for prolonged period of time.[16]

Carpal tunnel syndrome occur as a result of trapping the median nerve in the level of wrist and electroneuromyography (ENMG) is again the most important examination tool in order to both diagnose and classify this disease. Decrease in the sensory conduction velocity of the nerve is the earliest electrophysiological abnormality that can be observed in CTS.[17]

Also our findings were supported by Faik et al., 2018 who conducted a research to investigate the effect of smart phone usage on the median nerve, found that the median nerve conduction velocity was faster and latencies were lower in low smartphone users compared to others. It has been specified that repetitive wrist extension and flexion movement, also the extension style finger movements can increase the pressure in the carpal tunnel ,they conclude that frequent usage of smart phones can lead to CTS by adversely affecting the median nerves.[16]

Smartphone users typically adapt their thumb and hand postures to the constraints of the phone design layout that may impact their performance. Incorrect posture, such as prolonged flexion of the wrist and repetitive use of the thumb, may impact the median nerve and the structures in the hand.[18]

The observation of the significant decrease in the sensory nerve conduction velocity due to the frequent use of smart phones, which is a well-known early parameter of CTS, let us think that the repetitive wrist extension and flexion movement, also the extension style finger movements can increase the pressure in the carpal tunnel.[19]

Also, our findings were supported by Inal et al., 2015 ,who conducted a study to investigate the effects of smart phones over use on function, pinch strength, and the median nerve, they demonstrated that median nerve is enlarged in people who frequently use smart phones and this can be associated with CTS**,** they concluded that Smartphone overuse enlarges the median nerve, causes pain in the thumb, and decreases pinch strength and hand functions.[20]

As regard to ulnar nerve**,** there was significant difference between both groups in the conduction velocity in the forearm but there was no significant difference between both groups in distal latency as well as the conduction velocity at arm, this can be related to prolonged elbow flexion during smart phone usage that can over stretch the ulnar nerve around the medial epicondyle.

Because of the anatomical conditions, posture, especially prolonged elbow flexion, may play a crucial role in determining direct mechanical or vascular-mediated (through vasa nervorum compression) injury, causing focal demyelinating and/or axonal damage. Beside elbow flexion, the phone call posture involves the wrist as well (usually with extension) and the flexor carpi ulnaris muscle, to maintain the cell phone in the appropriate position for listening and speaking, with further potential damage to the ulnar nerve.

Extreme elbow flexion is known to facilitate transient ulnar nerve damage, and prolonged elbow flexion is considered a provocative test (as Phalen test for carpal tunnel syndrome.[21]

In addition to this explanation relationship between the elbow joint angles and the ulnar nerve, flexion of the elbow causes increased tensile load on the ulnar nerve as well as increasing the pressure within the cubital tunnel up to 20 times the pressure at rest.[22]

Our findings were supported by Samaan et al., 2018 who conducted a research to investigate effect of prolonged smart phone use on cervical spine and hand grip strength in adolescence, they reported that there is a significant difference between the users and non-users groups, the users group were less than non-users in ulnar nerve conduction velocity but still within lower limit of normal level (55m/s). This demonstrated that prolonged use of smart phone affects the ulnar nerve conduction velocity due to sustained neck flexion due to looking downward at the smart phone 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, they concluded that 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[23].

As regard to grip strength was assessed by dynamometer our study showed that there was no significant difference between both groups.
Our findings were supported by Samaan et al., 2018, who conducted a research to investigate effect of prolonged smart phone use on cervical spine and hand grip strength in adolescence, they reported that the strength of handgrip was not affected by prolonged neck flexion at this age but they expect that muscles of handgrip especially innervated by ulnar nerve may be affected in old age after many years of smart phone use[23].
Our findings was contradicted with Dakoria et al., 2017 , who conducted a research to investigate association of excessive smartphone usage and grip strength among young adults**,** they reported that there was weak association between Smart phone usage and grip strength, this disagreement can be related to their small sample size as they conduct it on 30 subjects only[24].

Conclusion

According to the results of this study it can be concluded that extensive use of smart phone have an adverse effect on motor and sensory distal latencies of median nerve , also on the motor conduction velocity of ulnar nerve at forearm level.

Implementations:

1. Extensive use of smart phones is not recommended and usage should not exceed 2 hours per day.
2. The users who use the smart phone extensively are more liable to upper limb entrapment and or neuropathies.

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