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Electrophysiological studies of upper trapezius and abductor pollicis brevis muscles during smartphone usage with different dominant hands in adolescent age: A pre-experimental study.

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Abstract

Background: Smartphone has been increasingly used many times daily. Unfortunately, its excessive usage is associated with different musculoskeletal disorders through affecting muscles function of the upper limbs.

Objectives: The aim of this study was to evaluate electrical muscle activity of upper trapezius and abductor pollicis brevis muscles in relation to dominant hand type while using a smartphone. Methods: A one group experimental study was conducted on healthy one-hundred and fifty children with age 12 – 14 years from both sexes. The electrical activities of their right and left upper trapezius and abductor pollicis brevis muscles were recorded by electromyography at 6 time points; 0, 10, 15, 20, 25, and 30 minutes while using the smartphones.

Results: The results showed that the majority of children had a right dominant hand (82%). After starting smartphone use, electrical activity of the right and left upper trapezius and abductor pollicis brevis muscles declined significantly at each time point (p-value < 0.05). This reduction was significantly influenced by increased body mass index for the right and left muscles, left dominant hand for the right muscles, and right dominant hand for the left muscles. Moreover, abductor pollicis brevis muscles were more affected than upper trapezius muscles indicated by time to maximum reduction in the electrical activity (10 *versus* 15 minutes) and partial eta-squared. The partial eta squared for the effect of time interacted with dominant hand type is 3.2% and 5.6% for the right and left trapezius muscles compared to 12.5 % and 36.4% for the right and left abductor pollicis brevis muscles, respectively.

Conclusion: Reduction in muscle activity is an adverse effect from smartphone excessive use; optimal usage time should be established to guide its use, especially among children.

Keywords: Abductor pollicis brevis, Electrical activity, Fatigue, Motor, Smartphone, Upper trapezius.

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Introduction

A smartphone is a mobile phone that has advanced functionality beyond making phone calls. It can display photos, play videos, check, and send e-mail, surf the Web, and run third-party applications, which provides limitless functionality.

Smartphone use among healthcare providers has become widespread on a daily basis in order to perform their tasks including medical applications and websites [1].

It improves communication between physicians, nurses, and allied health professionals [2]. However, excessive use of smartphone has been associated with adverse effects including headache, impaired concentration, memory disturbance, sleeplessness, hearing problems, and facial dermatitis [3]. Tension and fatigue were also reported [4].

Of note, the musculoskeletal disorders related to extensive and chronic smartphone use has been studied. It was found to had a prevalence of 8.2%-89.9%, especially neck and upper back complaints which had the highest prevalence of 55.8%-89.9% [5]. Long-term effects on in neck and upper extremities were also reported [6].

In a retrospective study conducted on 70 subjects, pain in the thumb and forearm in presence of burning, numbness and tingling around the thenar aspect of the hand, and stiffness of wrist and hand were reported among all the subjects.

They were diagnosed with tendinosis of extensor pollicis longus and myofascial pain syndrome [7].

In another study conducted on 27 hand held devices, myofascial pain syndrome of adductor pollicis was found in

70.37%, thoracic outlet syndrome was found in 51.83%, and fibromyalgia syndrome was found in 25.93% of subjects [8].

In general, the most common musculoskeletal disorders symptoms associated with smartphone use were pain and the most common pathology were myofascial pain syndrome, fibromyalgia, thoracic outlet syndrome, tendonitis, and De Quervain's syndrome [5].

Risk factors associated with the musculoskeletal disorders are frequent repetitive movements of a certain body part, occupational risk, specific positions such as prolonged sitting, or standing, while risk factors associated with smartphone use-related musculoskeletal disorders are time and intensity of smartphone use, and head position [5,9,10].

Upper extremities muscle fatigue and reduction in muscle activity as acute effects of smartphone use have also been studied.

An increased fatigue and a reduction in median frequencies of the upper extremity and neck muscles and a reduction in pressure pain threshold of the upper trapezius were reported after using a smartphone or computer [11].

Moreover, the use of a smartphone for those with preexisting neck pain further increased muscle tenderness and fatigue in the cervical erector spinae and upper trapezius and reduced both pressure pain threshold and the cervical range of motion [12].

The high-quality electromyography (EMG) has been shown to be safe and reliable device to measure muscle fatigue in all settings, including acute care environment [13,14].

Therefore, we aimed to evaluate muscle activity of upper trapezius and abductor pollicis brevis muscles while using a smartphone in a time-dependent manner in regards to dominant hand types.

Materials and Methods

Subject

Healthy one hundred and fifty subjects with the following inclusion criteria were recruited: Subjects with any gender, had age from 12 to 14 years, and signed the informed consent form to participate in this study.

The study subjects were recruited from Long Live Egypt School in El-Asmarat compound. The current study was conducted in Al-Hussein University Hospital, Neurology department, Cairo, Egypt during the period of (February 2020 to September 2020).

We excluded children who enrolled in any regular athletic activity, unconscious, those with neck pain, upper limb, and spinal deviation, had rheumatoid arthritis, or woker children.

Ethical approval

The study was ethically accepted by the ethical committee of the Faculty of Physical Therapy, Cairo University, Egypt with number NO: P.T.REC/012/002543 and registered at Clinical Trials Registry (Registry ID / NCT04641208).

Sample size calculation

G*POWER statistical software was used to calculate the sample size (version 3.1.9.2).

For one group with two positions repeated measures the minimum required sample size was 64. (F tests- Repeated measures, within factors, α=0.05, β=0.2, and medium effect size = 0.25).

Design

Pre-experimental pretest and posttest design

Materials

Electromyography

Evaluation of muscle activity was carried out using EMG machine (Deymed Diagnosti EMG model true trace 2 channel made in the Republic Cech in 2015) to recorde the electrical activity produced by skeletal muscles [15].

Procedure

Each child sat on a chair with his feet on the floor and elbow slight flexion, holding a smartphone on their favorite positions to use smartphone.

The EMG was prepared by placement of electrodes on the skin, using straps to avoid movement of electrodes, and ensuring that the wires were not lose to avoid any stress on the wires and avoid placing electrodes over scars.

During recording, care was taken that the room was quite to avoid any change in the reflex value results.

Assessment was done at 6 time points within the testing session; at baseline and after 10 min, 15 min, 20 min, 25 min and 30 min from start using the smartphones.

For recording the maximum isometric contraction of upper trapezius muscle, electrode was placed on the angle of neck and shoulder.

For recording maximum isometric contraction of abductor pollicis brevis, electrode was placed on midpoint of the first metacarpal just medial to the bone.

Muscle fatigue was detected by the following changes in the EMG signal: an increase in the mean absolute value of the signal, increase in the amplitude and duration of the muscle action potential, and an overall shift to lower frequencies.

Statistical method

One-way repeated analysis of covariance (ANCOVA) as a repeated measure test was used to investigate the significance and quantify the effect of time, dominant hand type, and BMI on the change in electrical activity of two muscles on the right and left sides over 30 minutes during using a smartphone.

The effect sizes were quantified using Partial Eta squared (ηp2). Additionally, the combined effects of each of dominant hand type and BMI with time were tested as an interaction terms (BMI X time and DH X time) in the same repeated ANCOVA model.

Post hoc analysis using Bonferroni test was conducted to test difference between each consecutive time points.

The assumptions of repeated ANCOVA were also tested and ensured to be met before conducting the analysis.

Greenhouse-Geisser correction was used when the assumption of sphericity was violated. All tests were conducted at a level of significance of 0.05.

Results

The children of the present study showed age ranged from 12-14 years with mean age of 12.91 ± 0.8 years, mean weight of 53.68 ± 14.07 kg, mean height of 155.38 ± 6.7 cm, and BMI of 22.13 ± 4.91 kg/m^2. Males were 49% and children with right dominant hand were 82% of the studied children.

Right and left upper trapezius

Electrical activity of the right upper trapezius had mean ± SD at 0, 10, 15, 20, 25, 30 time points of 15.45 ± 2.232, 13.97 ± 1.904, 12.10 ± 2.051, 11.84 ± 2.047, 11.16 ± 2.3, 10.52 ± 2.221 respectively and electrical activity of the left upper trapezius had mean ± SD at 0, 10, 15, 20, 25, 30 time points of 14.11 ± 2.501, 13.03 ± 2.650, 9.03 ± 2.650, 8.03 ± 2.650, 7.28 ± 2.546, 6.30 ± 2.520 respectively after starting use of smartphone.

The one-way repeated ANCOVA showed that the opposite side dominant hand and time had a significant negative effect on the electrical activity of the right and left upper trapezius muscle.

However, the right muscle was also affected by increased BMI.

Moreover, reduction rate in the electrical activity was accelerated with increase in BMI for both sides, with left dominant hand for right side, and with right dominant hand for left side concluded from the interaction terms with time as shown in table 1 and figures 1 & 2.

Post hoc analysis showed that the reduction at each time point was significant compared to the previous time point.

Of note, the maximum reduction in the muscle activity was achieved after 15 minutes.

Partial eta squared for the effect of time modified for dominant hand type is 3.2% for the right side and 5.6% for the left side.

Factors	Rt. UT		Lt. UT	Rt. APB	Lt. APB			
	F	P-value	F	P-value	F	P-value	F	P-value
Time	8.159¥	0.000*	190.84¥	0.000*	7.775¥	0.001*	14.7¥	0.000*
Time X BMI	44.305¥	0.000*	8.625¥	0.000*	44.35¥	0.000*	89.19¥	0.000*
Time X DH	5.184¥	0.006*	9.212¥	0.000*	22.34¥	0.000*	89.42¥	0.000*
BMI	22.127	0.000*	3.566	0.061	4.153	0.043*	26.33	0.000*
DH	9.22	0.003*	71.305	0.000*	6.346	0.013*	404.55	0.000*

Table 1. Effect of smartphone on the right and left upper trapezius and abductor pollicis brevis muscle activities over the time, using one-way repeated ANCOVA.

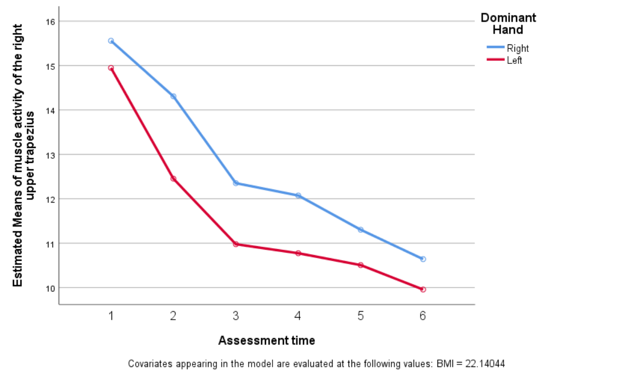

Figure 1. Reduction in electrical activity of the right upper trapezius muscle over the time stratified by dominant hand type.

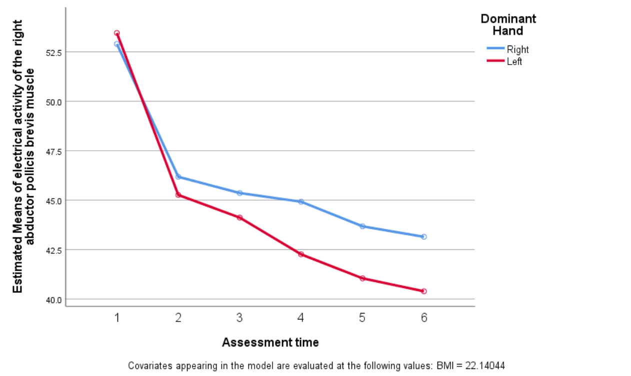

Figure 2. Reduction in electrical activity of the right abductor pollicis brevis muscle over the time stratified by dominant hand type.

Right and left abductor pollicis brevis

Electrical activity of the right abductor pollicis brevis had mean ± SD at 0, 10, 15, 20, 25, 30 time points of 53.00 ± 2.259, 46.01 ± 3.176, 45.13 ± 3.156, 44.43 ± 3.882, 43.19 ± 3.702, 42.64 ± 3.959 respectively and electrical activity of the left abductor pollicis brevis had mean ± SD at 0, 10, 15, 20, 25, 30 time points of 49.73 ± 4.185, 42.33 ± 5.641, 41.26 ± 5.612, 39.84 ± 4.263, 38.53 ± 4.266, 37.42 ± 5.321 respectively after starting use of smartphone..

The one-way repeated ANCOVA showed that the increased BMI, the opposite side dominant hand and time had a significant negative effect on the electrical activity of the right and left upper trapezius muscle. Moreover, reduction rate in the electrical activity was accelerated with increase in BMI for both sides, with left dominant hand for right side, and with right dominant hand for left side evident by the interaction terms with time as shown in table 1 and figures 3 & 4. Post hoc analysis showed that the reduction at each time point was significant compared to the previous time point. Of note, the maximum reduction in the muscle activity was achieved after 10 minutes. Partial eta squared for the effect of time modified for dominant hand type is 12.5 % for the right side and 36.4% for the left side.

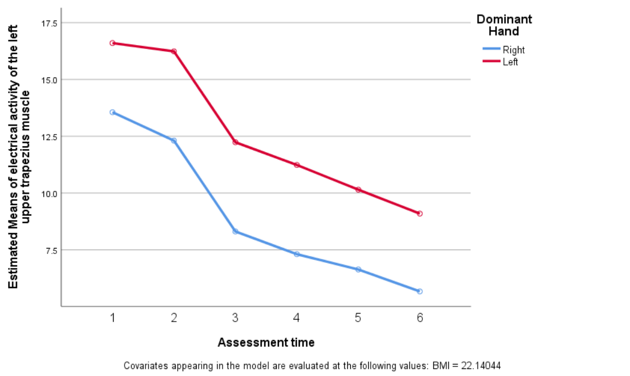

Figure 3. Reduction in electrical activity of the left upper trapezius muscle over the time stratified by dominant hand type.

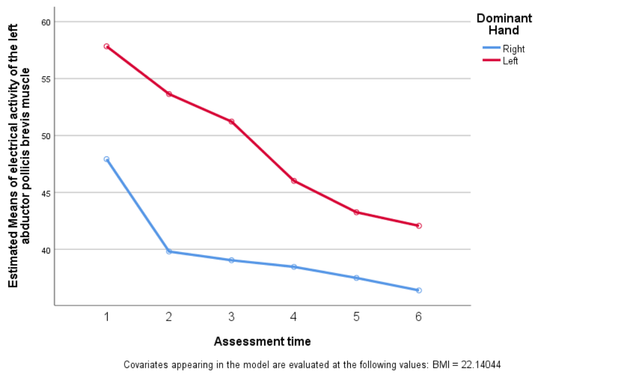

Figure 4. Reduction in electrical activity of the left abductor pollicis brevis muscle over the time stratified by dominant hand type.

Discussion

Smartphones are used more commonly in everyday life, and their users are likely to be affected both physically and psychologically.

The entire society, particularly health professional, should intensify their efforts in relation to the use of smartphones. There are few studies that discussed time-dependent and long-term physical impacts of smartphone use. Therefore, we investigated muscle fatigue in a time-dependent manner aimed to answer the question of how long smartphone should be used.

In this study, we investigated muscle fatigue by measuring electrical activity of two different muscles at 6 time points from starting use of smartphones. The results of this study yielded an increased muscle fatigue of the upper limbs and risk of musculoskeletal disorders among smartphone users indicated by the reduction in the muscle electrical activity. The study subjects showed a significant reduction in activity of the all studied muscles after 10 minutes from start using the smartphones.

Moreover, this reduction was continued in a time-dependent manner, and each decline was significant when compared with the previous recorded activity. We chose two different muscles of the upper limb with different sizes to investigate amount of reduction and to compare between them. What we have found is that the larger muscle, the upper trapezius, got less fatigue and showed more resistance than the smaller one which was the abductor pollicis brevis muscles. We also examined the effect of each of BMI and dominant hand on the electrical activities measured along the 30 minutes at 6 time points. Additionally, we also examined the effects of BMI and dominant hand on the rate of reduction in the muscle activity, and we found significant effects for both BMI and dominant hand type on the reduction rates. Consistently, a study was conducted on total 34 participants assigned into 3 groups. It reported that the group that used the smartphone for 10 minutes showed a reduction in median frequency of fatigue in all muscles studied, but not significant. However, in the 20-minute group, the reduction in the upper trapezius was significant [16]. In comparison with our findings, we have got significance after 10 minutes as we have a larger sample size and more power. Another study which was conducted in Korea on 17 subjects found that the median frequency of upper trapezius decreased significantly after 20 minutes of smart-phone use [17]. It did not measure muscle activities at other time points.

Because the present study participants held smartphones on their favorite positions, some of them were holding their phones in incorrect positions, which could have harmed their muscles and joints. Some participants in this study primarily used their smartphones with their heads lowered, resulting in fixed postures with flexed necks. Looking downward encourages muscle fatigue more quickly than looking upward, according to Kim et al. [18]. Looking downward is more likely to cause muscle fatigue than looking upward.

Although we only looked at one session per subject, children with wrong position may be exposed to cumulative pain if they use smartphones on a regular basis. There are some drawbacks to this research. Only short-term use yielded differences, but not long-term or continuous use as we did not have the opportunity to study these effects. Additional studies are needed regarding long-term adverse events of smartphone use, especially children.

Conclusion

A reduction in muscle activity and a subsequent muscle fatigue is a short-term adverse effect of smartphone use, especially with small muscles. Optimal duration time to use smartphones should be instified, especially among children to minimize the risk of musculoskeletal disorders associated with their use.

Abbrevations:

Rt: Right, Lt: Left, UT: Upper Trapezius, APB: Abductor Pollicis Brevis, BMI: Body Mass Index, DH: Dominant Hand, ¥: Greenhouse-Geisser Correction, *: Significant p-value at 0.05 level of significance

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