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ORIGINAL RESEARCH ARTICLE

Myoelectrical activity of sternocleidomastoid muscle in smartphone-addicted versus non-addicted individuals

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Abstract

Background Over the past decade, smartphone users have substantially increased, raising concerns about potential musculoskeletal problems associated with long-term use. Prolonged smartphone usage may cause discomfort in the thumb, shoulder, and neck that can be exacerbated over time, thereby affecting the electrical activity of several muscles, such as the sternocleidomastoid muscle (SCM). Accordingly, we aimed to examine the impact of smartphone addiction on the myoelectric activity of the SCM.

Design and method Forty-four smartphone users, both male and female, aged 18–30 years, were recruited from the Faculty of Physical Therapy, Cairo University, in this observational study. The participants were equally allocated into two groups, A and B, based on their Smartphone Addiction Scale-Short Version (SAS-SV) scores. Group A consisted of smartphone-non-addicted users who scored below 31 for males and 33 for females, whereas group B included smartphone-addicted users who scored over 31 for men and 33 for females. Additionally, the electromyography (EMG) device was used to monitor the electrical activity during rest and maximum voluntary contraction (MVC).

Results The results showed a significant difference ($P < 0.0001$) in the electrical activity of the left and right SCMs between the two groups at rest but a nonsignificant difference during MVC.

Conclusion Smartphone addiction significantly impacts the myoelectric activity of the SCM at rest among young adult smartphone users, but this impact is not significant during MVC.

Keywords Smartphone addiction, Sternocleidomastoid muscle, Electromyography, Maximal voluntary contraction

Introduction

The last decade has witnessed increased mobile phone usage, leading to concerns that excessive use of these devices may contribute to musculoskeletal problems. Prolonged usage of smartphones promotes repetitive strain on particular muscles, perhaps resulting in overuse injuries to the muscle fibers. The shoulders and neck are commonly impacted by injuries caused by muscle tension and sudden trauma [1]. The increasing popularity of smartphones and other mobile devices has resulted in a higher frequency of digital activities that were traditionally performed on desktop and laptop computers. Research has explored the internet usage of older adults, but the knowledge about their specific smartphone interactions is limited. This is mostly because smartphones are internet-connected gadgets that provide various applications such as gaming, music streaming, and social networking [2]. Although smartphones can assist users in maintaining communication with friends and family, managing tasks, and increasing accessibility, their excessive usage can cause adverse effects [3]. Smartphone users were estimated to be 3.6 billion in 2016 and

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increased to 6.5 billion in 2020, representing over one-third of the global population [4].

Recently, research has raised concerns regarding the shoulders and neck areas among smartphone users [5]. Individuals who operate remotely on a computer may experience severe effects on the sternocleidomastoid muscle (SCM) due to forward head posture (FHP) [6]. Using a smartphone for texting requires bending the head to view and tapping the screen, resulting in a persistently slouched posture, repetitive movements, work-related stress [7], and severe neck muscular fatigue, which exacerbates pain over time [8]. Additionally, Yang et al. [9] have demonstrated an association between musculoskeletal pain and smartphone usage duration. Therefore, we aimed to examine the impact of smartphone addiction on the myoelectric activity of the SCM.

Materials and subjects

Study design and subjects

Our study aimed to examine the impact of smartphone addiction on the myoelectric activity of the SCM. This observational study recruited 44 subjects from the Faculty of Physical Therapy at Cairo University between August 2023 and October 2023. The participants were from both genders (21 males and 23 females), aged 18–30 years, with a body mass index (BMI) of 19.5–29.4 kg/m^2. The participants were equally allocated into two groups, A and B, based on their Smartphone Addiction Scale-Short Version (SAS-SV) scores. Group A consisted of smartphone-non-addicted users who scored below 31 for males and 33 for females, whereas group B included smartphone-addicted users who scored over 31 for men and 33 for females. The inclusion criteria were (1) individuals aged between 18 and 30 years and (2) individuals utilizing a smartphone with a 6.7-inch touch screen. Exclusion criteria included individuals with neck pain (spondylosis and disk prolapse), systemic diseases, spinal deviation, and prior neck surgery. The study protocol was approved by the research ethical committee of the Faculty of Physical Therapy (NO: P. T. REC/012/004614) and registered at the Clinical Trial Registry (NCT06112496). Participants were provided with a detailed explanation of the aim and protocol of the study before participation, and they signed an informed consent.

Sample size calculation

The sample size was calculated using G-power analysis (version 3.1.9.2, Franz Faul, Uni Kiel, Germany) to be 44, which was allocated equally into two groups ($n=22$/group). Using electromyography (EMG) activity as the primary outcome, the calculation aimed to reveal an impact size of 0.5, with a significance level of 0.05 and a statistical power of 80%.

Assessment procedure

Demographic data, including age, weight, height, and BMI, was obtained from all participants. A universal height and weight scale (Model Number: Zt–120 Dial Body Scale, Perlong Medical Equipment Co., Ltd., Shanghai, China) was used to determine the height and weight of the subjects to calculate the BMI. The BMI was calculated according to the following formula: $\text{BMI (kg/m}^2) = \frac{\text{Weight (kg)}}{\text{Height}^2\text{ (m}^2)}$ [10]. Following the procedure for choosing participants based on inclusion and exclusion criteria, the participants completed the SAS-SV questionnaire. The SAS-SV self-reporting questionnaire is a valid and reliable scale for smartphone addiction consisting of six factors and ten items with a six-point Likert scale (1: "strongly disagree" and 6: "strongly agree"). The six factors are daily-life disturbance, positive anticipation, withdrawal, cyberspace-oriented relationship, overuse, and tolerance [11, 12]. Those scoring below 31 for males and 33 for females were classified as smartphone-non-addicted, while those scoring above 31 for men and 33 for women were considered smartphone-addicted [11]. Subsequently, we measured the amplitude and root mean square (RMS) through a surface EMG unit during rest and maximum voluntary contraction (MVC). The entire testing procedures were completed in a single session.

Recording EMG activity

The SCM was assessed once from both sides using EMG were recorded using two EMG channels (Neuro–MEP.NET, Neurosoft, and Ivanovo, Russia) version 4.1.7.0 in labs of Faculty of Physical Therapy, Cairo University, while simultaneously performing maximum voluntary isometric contraction (MVIC). Methylate alcohol was applied to cleanse the skin above the SCM, then rubbed with dry and clean cotton. This treatment was repeated until the skin became red to reduce skin resistance. Great care was considered to ensure that the skin under the recording electrode was neither damaged nor irritated. The electrode for monitoring SCM activity was placed 2 cm from the C4 cervical vertebra (Fig. 1), with the ground electrodes attached near the wrist [13]. The central region of the SCM was examined by applying pressure during neck flexion against resistance, 3 cm above its front end in the posterior triangle of the neck. The participant was directed to perform isometric contraction of the neck flexors for 3–5 s to ensure accurate placement of the electrodes [14]. The testing and laboratory conditions remained consistent during the investigation, with the same physiotherapist conducting each test.

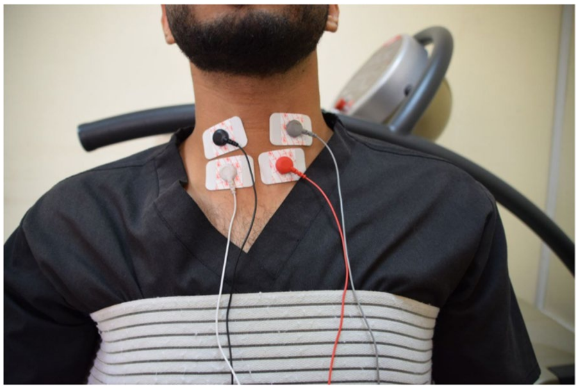

Fig. 1 Position of electrodes

Fig. 3 Maximum isometric contraction for sternocleidomastoid

Assessment muscle amplitude at resting position

The participants were asked to relax as much as they could (Fig. 2), and the resting amplitude was recorded three times, followed by assuming the average [14].

Assessment of MVIC and normalization of SCM

The subject performed a static contraction of neck flexion with the arms beside the body while sitting (Fig. 3) [3]. Resistance was provided with manual resistance on the forehead. Every contraction lasted for 7 s and was performed three times with a break of 30 s between each contraction [14]. The MVIC measures the SCM muscles primarily in resisted flexion [15].

Fig. 2 Assessment of amplitude at resting position

Analysis of EMG data

An amplitude-time display of the EMG recordings was used to visually inspect the EMG responses to ensure that any evident artifacts were removed. Prior to quantifying the EMG variable, factors such as electrode noise, motion artifact, and DC (direct current) artifact were removed [16].

Normalization to MVIC was conducted through normalized RMS, where the participants performed three MVICs, each lasting 7 s, with intervals of 30 s between each contraction. The experimenter provided verbal support during each normalization trial [16].

Statistical analysis

All statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA). The data was tested for normal distribution using the Shapiro–Wilk test, and variance homogeneity between groups was verified with Levene's test. An unpaired *t*-test was used to compare subject characteristics between groups and to compare RMS of the SCM between groups and between females and males. The chi-squared test was employed to compare sex distributions. All statistical tests were conducted with a significance level of $P < 0.05$.

Results

Subject characteristics

Table 1 in Appendix shows that basic characteristics, including age, weight, height, BMI, and sex distribution, did not differ statistically between groups ($P > 0.05$). The SAS-SV of group B was significantly higher than that of group A ($P < 0.001$).

Comparison of RMS at rest and activity of SCM between groups

The RMS at rest in the left and right SCMs was significantly higher in group B than in group A ($P < 0.01$; Table 2 in Appendix and Fig. 4). Between-group differences in RMS during contraction of the left and right SCMs were nonsignificant ($P > 0.05$; Table 2 in Appendix and Fig. 5).

Comparison of RMS at rest and activity of SCM between females and males

The results revealed a nonsignificant difference in RMS at rest and during right and left SCM activity between females and males of groups A and B ($P > 0.05$; Table 3 in Appendix).

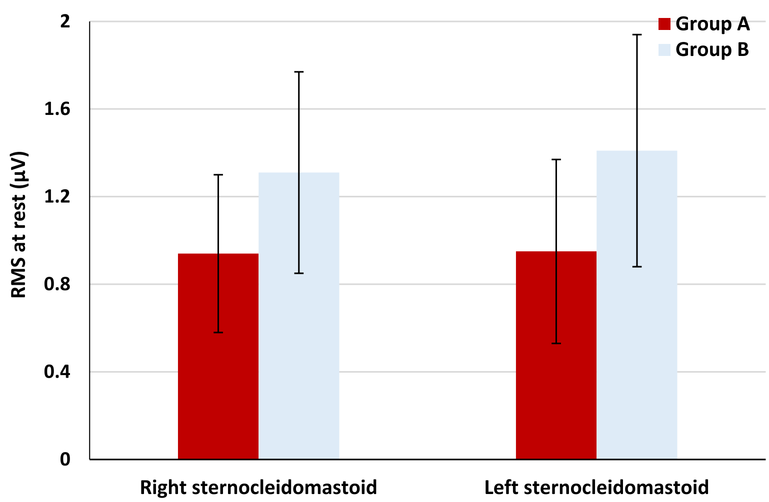

Fig. 4 Mean RMS of sternocleidomastoid muscle at rest of groups A and B

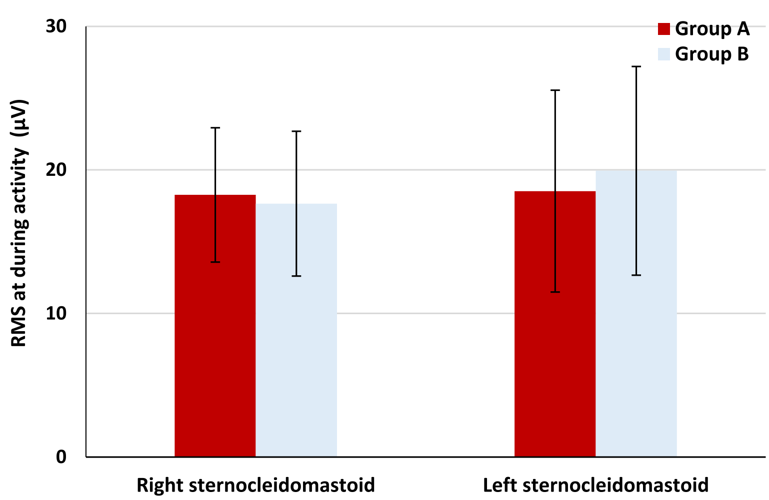

Fig. 5 Mean RMS of sternocleidomastoid muscle during activity of groups A and B

Discussion

The increasing smartphone usage over computers daily has caused numerous adverse effects of smartphone addiction. Smartphone users engage in many activities such as browsing the internet, using social media, chatting, gaming, gambling, listening to music, and more on their devices [17]. During these tasks, individuals may remain in one posture for an extended period without moving or doing repetitive movements, which might result in numerous musculoskeletal disorders [1]. Particularly, text messaging, a prominent smartphone app category, could be a key contributor to causing neck pain in frequent smartphone users [18]. Using smartphones often involves looking down or extending arms forward to view the screen, leading to an FHP that can strain the cervical spine and neck muscles due to excessive curvature in the vertebrae [19]. Improper posture of the head and neck attributed to smartphone use duration has been associated with chronic musculoskeletal pain [9, 20]. Musculoskeletal disorders affecting the hand, wrist, forearm, arm, and neck are on the rise globally due to the extended, forceful, low amplitude, repetitive usage of smartphones. Consequently, we examined the impact of smartphone addiction on the myoelectric activity of the SCM. Herein, we used SAS-SV to determine addicted and non-addicted smartphone users, owing to its strong validity and reliability in community and research settings to assess smartphone addiction [12]. Because adolescents use the internet extensively [21], they may postpone or not perform their school duties and responsibilities [22] and may have problems with academic performance [23]. Therefore, this instrument can be used conveniently in the screening process to determine those likely to be labeled "smartphone-addicted" in Egypt [24].

In the current investigation, SCM muscle activity was measured using EMG equipment depending on the surface EMG is a primary approach to record and studying muscle functioning. This is performed by recording the electrical muscle signal supports selecting an EMG machine for valid and reliable evaluation [25]. Moreover, MVIC is a highly important approach with high reliability and an important standard for measuring and evaluating how smartphone use affects muscle activity [26]. Our results showed that the electrical activity during MVC in left and right SCM did not significantly differ between A and B groups. However, both groups have significant differences in the electrical activity during rest. Moreover, RMS showed a nonsignificant difference during activity, possibly because of the small number of participants.

Consistent with Khan et al. [27] and Vitorino et al. [28], neck muscle activity increased when the head was shifted forward on the shoulder while using a smartphone. This supports the electrical activity measurement in the SCM muscle in addicted smartphone users. The young population has been reported to frequently adopt FHP and rounded shoulders due to prolonged usage of computers and smartphones. An FHP during sitting causes anterior shoulder position, upper cervical extension, and lower cervical flexion, resulting in deep cervical extensor shortening and deep cervical flexor extending and weakening. The upper and lower trapezius and the superficial cervical flexors, including the SCM, are activated more when the deep cervical flexors are less activated. These alterations increase stress and muscle tension in the shoulder and neck region during relaxation. Because smartphone addiction can alter muscle electrical activity, smartphones should be used for no more than 20 min to decrease musculoskeletal issues such as neck pain and muscular fatigue that are more common in the upper back, neck, and wrists/hands [29, 30]. In contrast to our results, Foltran et al. [31] have found that the resting RMS values of the bilateral masseter, temporalis, and left trapezius muscles exhibited a nonsignificant change before and after smartphone use. Collectively, smartphone addiction is associated with increased resting muscle activity in the SCM, emphasizing the importance of limiting smartphone usage to prevent neck pain and muscular fatigue.

Limitations

The study is limited by the small sample size of 44 participants, recruited from a single institution, which may limit the generalizability of the findings to a broader population. Additionally, the study focused on a specific age group (18–30 years), which could impact the applicability of the results to a more diverse population. The reliance on self-reported measures, such as the SAS-SV, may introduce bias and inaccuracies in assessing smartphone addiction levels. Furthermore, the study did not consider other potential confounding variables that could influence the outcomes, such as physical activity levels during smartphone use. These limitations should be considered when interpreting and applying the results of this study.

Conclusion

Smartphone addiction, as measured by the SAS-SV, was associated with increased resting EMG activity in the SCM muscles. However, there was no significant difference in EMG activity during muscle contraction between smartphone-addicted and non-addicted users. The findings suggest that excessive smartphone use may increase muscle activity in the neck muscles at rest, potentially contributing to musculoskeletal issues. Limiting smartphone usage to reduce the risk of neck pain and muscular fatigue is recommended.

Appendix

Table 1 Basic characteristics of participants

	Group A Mean ± SD	Group B Mean ± SD	*P* value
Age (years)	22.91 ± 3.18	23.36 ± 3.55	0.65
Weight (kg)	67.32 ± 8.79	66.59 ± 10.79	0.81
Height (cm)	169.45 ± 7.51	167.50 ± 9.75	0.46
BMI (kg/m^2)	23.35 ± 1.72	23.63 ± 2.31	0.65
SAS-SV	23.45 ± 4.88	44.86 ± 6.58	0.001
Sex, *n* (%)			
Females	10 (45.5%)	13 (59%)	0.36
Males	12 (54.5%)	9 (41%)	

BMI body mass index, *SAS-SV* Smartphone Addiction Scale-Short Version, *SD* standard deviation, *P value*, significance level

Table 2 Mean RMS at rest and activity of SCM of both groups

RMS at rest (μV)	Group A Mean ± SD	Group B Mean ± SD	MD	*t* value	*P* value
At rest					
Right SCM	0.94 ± 0.36	1.31 ± 0.46	− 0.37	− 2.86	0.007
Left SCM	0.95 ± 0.42	1.41 ± 0.53	− 0.46	− 3.15	0.003
At activity					
Right SCM	18.26 ± 4.68	17.65 ± 5.04	0.61	0.42	0.68
Left SCM	18.52 ± 7.03	19.94 ± 7.27	− 1.42	− 0.66	0.51

RMS root mean square, *SCM* sternocleidomastoid muscle, *SD* standard deviation, *MD* mean difference, *P value*, probability value

Table 3 Mean RMS at rest and activity of SCM of females and males

RMS (μV)	Group A					Group B				
	Female Mean ± SD	Male Mean ± SD	MD	*t* value	*P* value	Female Mean ± SD	Male Mean ± SD	MD	*t* value	*P* value
At rest										
Right SCM	0.99 ± 0.43	0.91 ± 0.31	0.08	0.51	0.61	1.35 ± 0.56	1.24 ± 0.31	0.11	0.51	0.61
Left SCM	0.91 ± 0.41	1.00 ± 0.44	− 0.09	− 0.49	0.63	1.54 ± 0.56	1.24 ± 0.49	0.3	− 0.49	0.22
At activity										
Right SCM	17.60 ± 4.20	18.83 ± 5.18	− 1.23	− 0.60	0.55	16.77 ± 3.81	18.94 ± 6.47	− 2.17	− 0.60	0.33
Left SCM	17.80 ± 7.11	19.12 ± 7.23	− 1.32	− 0.43	0.67	17.50 ± 3.97	23.48 ± 9.57	− 5.98	− 0.43	0.11

RMS root mean square, *SCM* sternocleidomastoid muscle, *SD* standard deviation, *MD* mean difference, *P value*, probability value

Abbreviations

BMI	Body mass index
EMG	Electromyography
FHP	Forward head posture
MVC	Maximum voluntary contraction
MVIC	Maximum voluntary isometric contraction
RMS	Root mean square
SAS-SV	Smartphone Addiction Scale-Short Version
SCM	Sternocleidomastoid muscle

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Authors' contributions
HM, EA, and HA contributed to the manuscript's conceptualization, methodology, supervision, investigation, and drafting. HM and EA contributed to supervising and reviewing the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets used and/or analyzed during the current study are presented in the tables and figures.

Declarations

Ethics approval and consent to participate
The study protocol was approved by the research ethical committee of the Faculty of Physical Therapy (NO: P. T. REC/012/004614) and registered at the Clinical Trial Registry (NCT06112496). Participants were provided with a detailed explanation of the aim and protocol of the study before participation, and they signed an informed consent, and all the methods were accomplished in agreement with the Declaration of Helsinki. All assessments and interventions were conducted at the Faculty of Physical Therapy at Cairo University between August 2023 and October 2023.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no conflict of interest.

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