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Association of Upper Extremity Pain with the Duration Spent on the Smartphone: A Cross Sectional Survey

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KK planned the project. AUR performed the research. JDM and GNP analyzed the data and interpreted the results. TM and RN developed the theoretical framework and wrote the article. All authors reviewed the results and approved the final version of the manuscript.

Key words
Smartphone, Joint pain, Muscle pain, Headache and hearing discomfort

ABSTRACT

The goal of this research was to look into the relationship between smartphone use and musculoskeletal discomfort among the youth of Karachi. We hypothesized that the amount of time participants spent on their smartphones might be associated with increases in musculoskeletal pain of upper extremity. A cross-sectional study observational survey was conducted on all smartphone users between the ages of 18 and 35. A total of 400 samples were randomly selected from various parts of Karachi. The data was collected between February and March utilizing Google forms as a web-based questionnaire. The questions in the study included excessive smartphone use on day to day basis that was causing referred discomfort in the upper extremities in the previous 30 days. Our findings indicate that as time spent on the smartphone increases, so do problems with the upper extremity's musculoskeletal system. Excessive smartphone use causes muscle fatigue and joint pain from the fingers to the neck, which is proportional to the amount of time spent on the device. The duration of smartphone ancillary function use was found to be related to the relationship between smartphone use and musculoskeletal discomfort in this study. Headache and hearing discomfort were found to increase in participants with increasing time, but this was not statistically significant.

INTRODUCTION

Smartphones have deeply penetrated the dynamics of everyday life, influencing informal interactions as well as their professional and health activities (Wilmer *et al*., 2017). These are the most extensively used portable electronic device nowadays. According to recent estimates, mobile phones are owned by at least 77% of the world's population (Schabrun *et al*., 2014). In addition, a recent research mentioned that 79% of people aged 18 to 44 keep their smartphones with them the most of the time, spending only two h of their working day without them. (Neupane *et al*., 2017). At the end of 2019, the number of smartphone users globally was anticipated to be 3.5 billion, with an estimate of 3.8 billion by 2021 (O'dea, 2020). The primary reason that smartphone use is growing in popularity around the world is that it is a most reliable communication and entertainment device (Kim, 2015).

Because people now use smartphones more frequently than computers on a daily basis, it's not surprising that a variety of negative consequences of increased smartphone use have surfaced (Cha and Seo, 2018). Smartphone users

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use their phones to surf the internet, utilize social media, talk with other users, play games, gamble, listen to music, and do a variety of other things (Cha and Seo, 2018; Haug *et al*., 2015). Often these smartphone tasks involve people to search down or retain their arms out in front of them to read the screen, that causes their head to move forward, causing an extreme anterior curve in the lower cervical vertebrae and an excessive posterior curve in the upper thoracic vertebrae to maintain stability, putting more strain on the upper spine and neck muscles (Berolo *et al*., 2011). Forward head posture is one of the most well-known bad postures in the sagittal plane. The repetitive process of sending messages, searching the internet, playing games, and other operations on a smart phone causes the user to repeatedly push the screen. These repetitive upper-extremity movements in static postures may cause uncomfortable feelings, pain, motor ability declines, and disease contraction (Gustafsson *et al*., 2010). As a result, it has been proven that prolonged and frequent smartphone use are key factors to the development of musculoskeletal problems (Bababekova *et al*., 2011; Gold *et al*., 2012). The musculoskeletal complaints, such as discomfort and pain, develop not just in neck as well as in the shoulders, elbows, arms, wrists, hands, thumbs, and fingers (Barr *et al*., 2004; Berolo *et al*., 2011; Gustafsson *et al*., 2010).

Smartphone users frequently experience a lot of symptoms, including headaches, muscle rigidity hand tremors, and finger numbness (Eom *et al*., 2013). According to (Berolo *et al*., 2011), users of mobile hand-held devices, complain of discomfort in at least one location of the upper extremities, upper back, or neck. Long-term smartphone use exerts constant mechanical stress on tendons, muscles, and perimetric tissue, leading to musculoskeletal symptoms of visual display terminal (VDT) syndrome (Ko *et al*., 2013; Ma *et al*., 2014).

A study found that mobile phones that encourage the use of only the thumb or one finger are connected with a higher prevalence of musculoskeletal diseases. Muscle activation and thumb location are influenced by the type of mobile phone task (holding vs. texting), as well as postures (sitting vs. standing) (Gustafsson *et al*., 2010). This usage pattern forces the user to maintain an abnormal position, such as forward neck flexion, for extended periods of time (Berolo *et al*., 2011; Gold *et al*., 2012; Gustafsson *et al*., 2010).

The number of people complaining of xerophthalmia, carpal tunnel syndrome, and other musculoskeletal system disorders has increased in conjunction with the rise in smartphone use, and the press and clinical literature are increasingly focused on the link between smartphone use and musculoskeletal system disorders (Berolo *et al*., 2011).

It is predicted that the frequency of mobile phone use, the purpose of mobile phone use, the degree of neck flexion when using the phone, and the body position are all important factors in neck pain, shoulder pain, joint pain, and its severity (Gustafsson *et al*., 2011; Lamberg and Muratori, 2012).

The aim of this study is to develop an explanatory framework that links the rise in upper extremity problems to long-term smartphone use at home.

MATERIALS AND METHODS

Participants

A cross-sectional observational survey was conducted on all smartphone users between the ages of 18 and 35 who were Karachi residents, using a self-administered online questionnaire. Over the course of four weeks, 450 questionnaires were distributed in the presence of the study teams. The participants gave their verbal consent after being fully informed about the study's objectives and the fact that they were going to be a part of it. The data was collected between February and March 2020 with 400 utilizing Google forms as a web-based questionnaire. Sampling was carried out at random. There is no discrimination or pre-set values for gender or marital status among the selective age group.

Inclusion criteria

The study included the participants, 18 to 35 years old who were Karachi residents, regardless of gender or handedness. They owned a smart phone for at least one year.

Exclusion criteria

Participants with any chronic medical condition, musculoskeletal disorders or anomalies, or those who had prior neck or shoulder surgeries, were excluded.

Design of the questionnaire

In order to meet the study's aims, a questionnaire was created. All of the questions in the survey were closed-ended, with just one correct answer.

The first section of the questionnaire included about their general demographics, such as their age, gender and marital status. The second section focuses into how much time users spend on their smartphones on a daily basis. Taking pictures and listening to music were removed since they demand the least amount of typing and holding of your smartphone, and are typically performed by other assistive tools such as selfie sticks, Bluetooth, and other similar devices. Participants were told that a typical day included both time spent at home and at work. The participants were also informed that all of the questions in

section 2 are purely about how they use their smartphones and the problems or discomforts they experience as a result of doing so.

The participant's well-being was the focus of Section 3 of the questionnaire, which was predicated on the hypothesis that excessive smartphone use was causing referred discomfort in the upper extremities. Participants were asked if they had (1) any pain in their neck, shoulder, elbow, wrist, or fingers, and (2) any pain in any of the muscles (3) hearing disturbances (4) which ear is most affected (5) headaches, in the previous 30 days.

For headache data on participants was collected in the study through Headache Impact Test-6 (HIT-6). The final HIT-6 score is derived from a simple sum of the six items and ranges from 36 to 78, with higher scores indicating greater impact. The severity level of headache impact can be classified using score ranges based on the HIT-6 interpretation guide, little or no impact (49 or less), mild impact (50–55), moderate impact (56–59), and severe impact (60–78) are the four headache impact severity categories (Yang *et al*., 2011).

Ethical consideration

The Institutional Review Board (IRB) at the Department of Community Health Sciences gave its approval for the study to be conducted. The participants were given verbal information regarding the study's objectives and nature. The participant's permission was assumed when they agreed to participate in the study. Timings were altered to accommodate the participants' hectic schedules in the event that they were unavailable to complete the questionnaire. Each participant was guaranteed anonymity and secrecy.

Pilot study

The results of the study were observed in a pilot study of 20 randomly selected participants.

Statistical analysis

The data entry and analysis of the collection data were done using SPSS version 23.0 on mac OS X (operating system). Before each questionnaire was submitted, it was extensively examined for missing data or information. All surveys that were missing relevant information were cleansed. The mean and standard deviation were employed for continuous variables, whereas, frequencies, and percentages were used for categorical data.

The Chi-Square test was performed to assess the time spent by the participant on his/ her phone at home with pain in joints, pain in participant's muscles, hearing discomfort, headache private life of the participants A p value of 0.05 was implemented as a threshold for significance.

RESULTS

The age, gender, and marital status criteria were mentioned in the demographic analysis. The total number of participants were 400, and they were divided into four groups based on their age: 20 years, 20–25 years, 26–30 years, and 31–35 years. According to our survey, 21.5% of participants were under the age of < 20, 51.5% were between the ages of 20 and 25, 14.0% were between the ages of 25 and 30, and 13.0% were between the ages of 30 and 35. Among the participants 63.50% were married and 36.50% unmarried (Table I).

Table I. Demographic characteristics of the participant.

Age (Mean ± S.D)	23.3 ± 9.2
< 20 Years (%)	21.5%
20 - 25 Years (%)	51.5%
26 - 30 Years (%)	14.0%
30 - 35 Year(%)	13.0%
Gender	
Female (%)	44.25%
Male (%)	55.75%
Marital status	
Married (%)	63.5%
Unmarried (%)	36.5%

Pain in joints of the upper extremity

The pain in the joints of the upper extremity, such as the finger joints, wrist joints, elbow joints, shoulder joints, and neck joint were assessed, but the time was divided into four categories: < 1, 1 to 2, 2 to 5 and > 5 h. The pain in the joints was analyzed independently in connection to the amount of time spent on the smartphone by the subjects (Table II).

Pain in finger and wrist joints

Thirty-eight (9.5%) people used their smartphones for less than an hour. Eighteen of them had never complained of finger and wrist joint, 4 of them experienced finger and wrist joint pain sometimes, and 16 complained frequent pain in the finger and wrist joint.

Among the 102 (25.5%) of the participants who used smartphone for 1 to 2 h, 44 did not complain of finger and wrist joint pain, 12 experienced finger and wrist joint pain sometimes, and 46 experienced finger and wrist joint frequently (Table II). Of those who (36.5%) used their smartphones for 2 to 5 h, 63 experienced frequent pain in finger and wrist joint. One hundred and fourteen (28.5%) of the individuals who used their smartphones for more than 5 h. Among them 15 had no finger and wrist joint pain, 49 had

Table II. Association of time spent by the participant on phone and pain in the upper extremity, musles, hearing discomfort, headache and joints.

Time spent	Finger	Wrist	Elbow	Shoulder	Neck	Total (%)	p-value
Pain in the joint							
< 1 h	10 (26.3)	11 (28.9)	09 (23.7)	06 (15.8)	02 (5.3)	38 (9.5)	< 0.001
1 h to 2 h	14 (13.7)	34 (33.3)	34 (33.3)	12 (11.8)	8 (7.8)	102 (25.5)	
2 to 5 h	25 (17.1)	38 (26.0)	49 (33.6)	26 (17.8)	8 (5.5)	146 (36.5)	
> 5 h	23 (20.2)	18 (15.8)	14 (12.3)	32 (28.1)	27 (23.7)	114 (28.5)	
	72	101	106	76	45		
< 1 h	10 (26.3)	11 (28.9)	09 (23.7)	06 (15.8)	02 (5.3)	38 (9.5)	< 0.001
Pain in the muscle							
	Palm	**Forearm**	**Arm**		**Neck**		
< 1 h	10(26.3)	12 (31.6)	7 (18.4)		9 (23.7)	38 (9.5)	< 0.001
1 h to 2 h	19 (18.6)	35 (34.3)	29 (28.4)		19 (18.6)	102 (25.5)	
2 to 5 h	24 (16.4)	54 (37.0)	48 (32.9)		20 (18.6)	146 (36.5)	
> 5 h	13 (11.4)	24 (21.1)	27 (23.7)		50 (43.9)	114 (28.5)	
	66						
Hearing discomfort							
	None	**Mild**	**Moderate**		**Severe**		
< 1 h	27 (71.1)	05 (13.2)	03 (7.9)		03 (7.9)	38 (9.5)	0.095
1 h to 2 h	44 (43.1)	35 (34.3)	20 (19.6)		03 (2.9)	102 (25.5)	
2 to 5 h	50 (34.2)	53 (36.3)	29 (19.9)		14 (9.6)	146 (36.5)	
> 5 h	78 (68.4)	26 (22.8)	09 (7.9)		01 (0.9)	114 (28.5)	
Headache							
	Never	**Sometimes**	**Frequently**		**Total (%)**		
< 1 h	17 (44.7)	15 (39.5)	06 (15.8)		38 (9.5)		0.539
1 h to 2 h	25 (24.5)	64 (62.7)	13 (12.7)		102 (25.5)		
2 to 5 h	32 (21.9)	80 (54.8)	34 (23.3)		146 (36.5)		
> 5 h	43 (37.7)	61 (53.5)	10 (8.8)		114 (28.5)		
Finger and wrist joint pain							
< 1 h	18	4	16		38 (9.5)		0.008
1 h to 2 h	44	12	46		102 (25.5)		
2 to 5 h	27	56	63		146 (36.5)		
> 5 h	15	49	50		114 (28.5)		
Elbow and shoulder joint pain							
< 1 h	18	5	15		38 (9.5)		0.002
1 h to 2 h	43	11	48		102 (25.5)		
2 to 5 h	15	51	80		146 (36.5)		
> 5 h	23	36	55		114 (28.5)		
Neck joint pain							
< 1 h	25	5	8		38 (9.5)		<0.001
1 h to 2 h	54	30	18		102 (25.5)		
2 to 5 h	11	61	74		146 (36.5)		
> 5 h	16	39	59		14 (28.5)		

Table continued on next page.....

Time spent	Finger	Wrist	Elbow	Shoulder	Neck	Total (%)	p-value
Palm muscle							
< 1 h	23	9	6		38 (9.5)		<0.001
1 h to 2 h	60	29	13		102 (25.5)		
2 to 5 h	22	60	64		146 (36.5)		
> 5 h	11	53	50		114 (28.5)		
Arm and forearm muscle							
< 1 h	23	9	2		38 (9.5)		0.003
1 h to 2 h	66	29	7		102 (25.5)		
2 to 5 h	22	59	65		146 (36.5)		
> 5 h	11	53	50		114 (28.5)		
Neck muscle							
< 1 h	32	3	3		38 (9.5)		<0.001
1 h to 2 h	50	31	21		102 (25.5)		
2 to 5 h	19	59	68		146 (36.5)		
> 5 h	20	36	58		114 (28.5)		

pain in the finger and wrist joint sometimes, and 50 experienced finger and wrist joint pain frequently (Table II).

Pain in elbow and shoulder joints

Of the thirty-eight (9.5%) who people used their smartphones for less than an hour. 18 complained of elbow and shoulder joint pain, and 15 complained of frequent elbow and shoulder joint pain. Of the (36.5%) of the participants used their smartphones for 2 to 5 h, 80 experienced elbow and shoulder joint pain frequently. Of the 114 (28.5%) individuals who used their smartphones for more than 5 h, 55 reported frequent elbow and shoulder joint pain (Table II).

Pain in neck joint

Thirty-eight (9.5%) people used their smartphones for less than an hour. 25 of them had never complained of neck joint pain, 5 of them sometimes complained of neck joint pain, and 8 complained of frequent neck joint pain. Of the 102 (25.5%) participants who used smartphone for 1 to 2 h, 54 had no neck joint pain, 30 sometimes experience neck joint pain, and 18 experienced neck joint pain frequently. Of the 146 (36.5%) participants used their smartphones for 2 to 5 h., 61 sometimes experience neck joint pain, and 74 experienced neck joint pain frequently. However, of the 114 (28.5%) of the individuals who used their smartphones for more than 5 h, 59 reported frequent neck joint pain (Table II).

Pain in the palm muscle

Thirty-eight (9.5%) people used their smartphones for less than an hour. Thirty never complained of palm muscle pain, 6 sometimes experienced palm muscle pain, and 2 complaints that palm muscle pain occur frequently (Table II), of the 146 (36.5%) of the participants used their smartphones for 2 to 5 h. 22 had no palm muscle pain, 60 sometimes experienced palm muscle pain, and 64 experienced palm muscle pain frequently (Table II). Among 114 (28.5%) of the individuals who used their smartphones for more than 5 h, 53 sometimes had palm muscle pain, and 50 experienced palm muscle pain frequently.

Pain in arm and forearm muscle

Out of 38 (9.5%) people used their smartphones for less than an hour, 23 had never complained of pain in arm and forearm muscle, 9 complained sometimes, while 2 complained of frequent pain in arm and forearm muscle. Among the one hundred and two (25.5%) of the participants who used smartphone for 1 to 2 h, 66 had pain in arm and forearm muscle, 29 sometimes experience pain in arm and forearm muscle, and 7 experienced pain in arm and forearm muscle frequently. Of the 146 (36.5%) of the participants who used their smartphones for 2 to 5 h. 59 experience pain in arm and forearm muscle sometimes, and 65 experienced pain in arm and forearm muscle frequently. Among 114 (28.5%) individuals who used their smartphones for more than 5 h, 55 reported frequent pain in arm and forearm muscle (Table II).

Pain in the neck muscle

Out of 38 (9.5%) people who used their smartphones for less than an hour, 3 complained of frequent neck

muscle pain (Table II), while 21 out of 102 experienced neck muscle pain frequently when used smartphone for 1-2 h, while 68 out of 146, 68 experienced neck muscle pain frequently when used smartphone for 2-5h.

Hearing discomfort

Out of 38 (9.5%) people who used their smartphones for less than an hour, 3 (7.9%) had severe complaint of hearing discomfort. When smartphone was used for 1 to 2 h, 43.1% experienced no hearing discomfort while only 2.9% experienced severe hearing discomfort. When smartphones were used for 2 to 5 h. 34.3% had no hearing discomfort while 9.6% had severe hearing discomfort. When smartphone used for more than 5 h, 68.4% experienced no hearing discomfort, while 0.9% experienced severe discomfort (Table II).

Headache

When smartphones were used for more than an hour, 44.7% complained no headaches, while 6 (15.8%) had experienced headaches frequently after usage for one hour, 12.7% after 1-2 h, 23.3% after 2-5 h (Table II).

The analyses revealed that there was significant increase in pain in finger and wrist joint ($p=0.008$), elbow and shoulder joint ($p=0.002$), neck joint ($p<0.001$), palm muscle joint ($p< 0.001$), arm and forearm muscle ($p=0.003$), neck muscle ($p<0.001$) with increasing time of smartphone used but no significant association between smartphone usage duration with hearing discomfort ($p= 0.095$) and headache ($p = 0.539$).

DISCUSSION

It is well known that smart phones are used at all times and in all locations since they are so easy to carry and use (Kobayashi and Yamaguchi, 2015). According to the findings of the current study, as time spent on a smartphone increased from 2 to 5 h and more than 5 h , there was a significant increase in complaints of upper body joint and muscle pain. The neck and shoulders may become painful when using a smartphone in a static position with an unsupported arm. Because smart phones have small monitors that are frequently held lower on the laps, therefore the users bend their necks to see the screens, activating the neck extensor muscles. Muscle fatigue, decreased labor capacity, and musculoskeletal effects result from overstretching the neck and shoulders (Kim and Koo, 2016). Also, long-term usage of smart phones causes repetitive use of certain muscles, resulting in muscle fiber injury and cumulative damages from acute injury to the neck, hand and shoulder muscles (Lee, 2002).

The study by (Tonga *et al*., 2017) mentioned that as the duration of use of a smart phone increases, users are more likely to develop severe musculoskeletal disorders, with symptoms including fatigue and pains in the upper extremities, such as the neck, shoulders, arms, wrists, back of the hand, and fingers, as well as pain in the waist. Users constant static motion reduces blood circulation, restricts nutrients from reaching muscles, and causes minor discomfort and tiredness (Janwantanakul *et al*., 2012; Kim and Kim, 2015).

In our study, we also found no significant association of increase duration of smartphone use with headache and hearing discomfort. According to a studies, poor postures cause fatigue, which has severe consequences such as decreased physiological function, disturbance of the autonomic nervous system, development of challenges in everyday life, and impacts both the visual and musculoskeletal systems, causing headaches and stress (Janwantanakul *et al*., 2012; Szeto and Lee, 2002). Similarly, a study published in 2016 by Montagni found no evidence of a link between non-migraine headache and smartphone use however, they reported that high levels of screen time exposure are linked to migraine in young adults (Montagni *et al*., 2016). Another study of the types and incidence of subjective symptoms associated with the use of smart phones in Poland users discovered that participants who spoke frequently and for long periods of time had more headaches than other users, and that 26% of the participants had a continuous headache that lasted more than 6 h after the call ended (Szyjkowska *et al*., 2014). In two studies on smartphone use, self-reported headache symptoms and frequency were used to classify headaches or migraines into categories based on the international classification of headache disorders-second edition (Society, 2004). One classified smartphone use as spending time on voice calls, (Milde-Busch *et al*., 2010) while the other defined phone use as duration of phone spent on during the day. Cerutti *et al*. (2016) also explored at the risk of smartphone usage and found no link between youth with and without headaches and smartphone usage. It is predicted that underlying mechanism of the association between mobile phone use and headache is unknown, but some speculate that exposure to low intensity mobile phone frequency microwave energy may cause a breakdown of the blood-brain barrier (Wang *et al*., 2017).

As previously stated in the present study, only a few participants experienced hearing discomfort; however, even after increasing their smartphone usage time, the majority of them did not experience hearing discomfort. Although the acute effects of smart phones on hearing have been studied, there is very little data on the chronic effects of mobile phone. Long-term mobile phone use has no effect on electrical stimuli transmission along the auditory

nerve to auditory brainstem centers. Therefore, in terms of the effects of mobile phones on hearing, the findings of the study by Gupta *et al* may appear in accordance with our study (Gupta *et al*., 2015).

The rapid development of smartphones has made them an unavoidable necessity in modern life; therefore, problems regarding the increased duration of smartphones and their impact continue to demand sustained attention.

Limitation of the study

The cross-sectional nature of this study's main limitation was that it did not provide a cause and effect link. This was due to the fact that the cross-sectional study only gives a snapshot of the prevalence and features of neck and upper extremity symptoms in a small group of smartphone users at a certain point in time.

CONCLUSION

Long-term smartphone use is critical for users because a variety of issues can emerge over time. The degree and types of symptoms that can develop in the upper extremity are linked to how much time a person spends on their phone therefore the participant's time spent may decrease. Keeping in mind that today's scientific and general markets demand the use of these technologically advanced gadgets. We must take responsibility for raising hazard awareness and implementing necessary preventative actions. Because the most common musculoskeletal pain in joints and muscles occurs in the upper extremity, less use of hand may result in a reduction in symptoms. Moreover, with adequate precautions, risk awareness, rehabilitation and physiotherapy, and use limitations, these measures resulting from the use of a handheld device could be avoided.

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IRB approval

Institutional review board approved the study by the IBR section HCM&D/CHS/1945/2019.

Ethical clearance

The project was approved by the University Ethical Committee.

Statement of conflict of interest

The authors have declared no conflict of interest.

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