Original Article

Association between smartphone use and carpal tunnel syndrome: A case-control study

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Abstract

Context: Carpal tunnel syndrome (CTS) is a common entrapment neuropathy of the upper limb. No published Saudi Arabian study has explored the effect of smartphones on the median nerve. **Aim:** To assess the association between smartphone use and the development of CTS. **Settings and Design:** This case-control study involved adults aged 18 years and older who visited King Khalid University Hospital (KKUH) in Riyadh, Saudi Arabia. **Materials and Methods:** Patients were clinically diagnosed with CTS, and the diagnosis was confirmed by a nerve conduction study (NCS) and electromyography. The controls were free of CTS based on the disease-specific Boston Carpal Tunnel Questionnaire. Statistical analyses were performed using IBM-SPSS version 25.0. **Results:** In total, 95 cases and 190 controls were included. Most of the participants were females (84.2%). The mean ages in the controls and cases were 34.6 +/− 10.2 years and 51.8 +/− 10.6 years, respectively. Using smartphones for 2 hours per day or more was significantly associated with the occurrence of CTS. After adjusting for covariates, 4 hours or more per day of smartphone use was associated with CTS. Moreover, those who held the smartphone with both hands had 7.8 times higher odds of developing CTS than those who held it with one hand. **Conclusion:** CTS has a negative impact on patients' daily activities and work. This study showed that an increased number of hours of smartphone use is associated with the development of CTS. Further prospective studies are needed to examine the long-term effects of smartphone use.

Keywords: Carpal tunnel syndrome, electronic devices, median nerve, mobile, smartphone

Introduction

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy and affects 3.8% of the general population.[1] Its prevalence varies widely in the literature, and it is believed that it affects females more than males.[2] Moreover, it is reported more frequently among workers,[3] especially those with occupations that involve exposure to repetitive, high-force work using vibrating tools.[4] Primary care physicians have an important role in the diagnosis and management of carpal tunnel syndrome. The majority of patients first present to their primary care doctors complaining of wrist pain or a tingling sensation.[5] Currently, we are observing further advancements in technology and other related industries. Thus, it has been reported that the incidence of work-related musculoskeletal disorders has rapidly increased.[6] Moreover, people are becoming more dependent on their smart devices, such as smartphones, which are expected to be used by 2.87 billion people worldwide in 2020.[7] Thus, it is anticipated that various adverse effects of smartphone use will appear.[8]

One study on the effect of using different types of electronic devices on university students found that 50% of the participants reported upper limb complaints, mainly in the neck and shoulder. Among these, 61.8% attributed those complaints to electronic device usage.[9] Another study conducted in China in 2017 reported that the duration of the use of electronic devices was strongly associated with the severity of pain and duration

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Received: 13-12-2020 **Revised:** 28-02-2021
Accepted: 12-03-2021 **Published:** 27-08-2021

Access this article online

Quick Response Code:

Website: www.jfmpc.com

DOI: 10.4103/jfmpc.jfmpc_2458_20

How to cite this article: Al Shahrani ES, Al Shehri NA. Association between smartphone use and carpal tunnel syndrome: A case-control study. J Family Med Prim Care 2021;10:2816-21.

of wrist/hand discomfort. However, this study was limited by the small sample size and relatively homogeneous study population.[10] Moreover, another study showed that excessive use of smartphones can affect the flexor pollicis longus (FPL) tendon and median nerve, causing pain in the thumb, decreasing hand functioning and pinch strength, and markedly increasing the median nerve size.[11]

Young adults are relatively more prone to developing musculoskeletal disorders because they more commonly use smart devices. Thus, the rapid hand movement involved in prolonged typing should raise concerns regarding the incidence of CTS in this population.[12] In Saudi Arabia, few studies have investigated CTS in the general population.[13-15] Some studies have explored the impact of occupation on the incidence of CTS.[16,17] Alosaimi *et al.*[18] reported that 27.2% of university students spent more than 8 hours/day using their smartphones. This finding may raise concerns about the development of musculoskeletal disorders in university students.[18] In addition, one study performed in the general population found that symptoms suggestive of CTS were significantly associated with younger age, female sex, higher body mass index (BMI) and occupation.[19] However, it did not clearly demonstrate an association of CTS with the pattern of electronic device use, probably due to the cross-sectional design and lack of diagnostic confirmation with electrophysiological studies.

Despite the negative impact of CTS, which can cause disability and often necessitates surgical intervention, there has been no study published in Saudi Arabia exploring the use of smartphones as a risk factor for CTS. This case-control study was performed to assess the association between smartphone use and the development of CTS in the adult population.

Material and Methods

Study design and setting

This was a case-control study that was performed at King Khalid University Hospital (KKUH) in Riyadh, Saudi Arabia, from February 2019–April 2020.

Target population

This study involved adults 18 years and above. Cases were defined as patients followed up in the neurology department who were clinically diagnosed with CTS, with diagnostic confirmation by a nerve conduction study (NCS) and electromyography (EMG), and used smartphones.

Controls were participants who were free of CTS based on the disease-specific Boston Carpal Tunnel Questionnaire.[20] These participants visited the outpatient clinics at KKUH and used smartphones.

The exclusion criteria for both groups were the diagnosis of conditions associated with CTS, such as diabetes mellitus (DM), rheumatoid arthritis (RA), hypothyroidism and hypertension, and the lack of smartphone use. However, due to the small sample size, we included patients who had risk factors for CTS (including DM, RA, hypothyroidism, and hypertension) and adjusted for these covariates in the analysis.

Sampling and sample size

A convenience sampling technique was used, and the sample size was calculated with the OpenEpi calculator based on a 95% level of confidence 95% ($\alpha = 0.05$). The estimated prevalence of exposure was between 10–35% among controls and cases, with a ratio of 1:2. The cases and controls were matched for sex. The sample size needed was 90 cases and 180 controls. To increase the power and avoid the effects of loss to follow-up, we decided to increase the sample size to 95 cases and 190 controls.

Data collection

Records of the patients who underwent an NCS and EMG in the electrophysiology lab at KKUH were reviewed for the period from November 2018 until April 2019 to identify patients with confirmed CTS who met the inclusion criteria.

The electronic files of 95 patients were reviewed to obtain their age, height, weight, medical conditions, and mobile numbers.

A validated data collection form was developed by the study authors through a literature review[9,10] and reviewed by two senior consultants. Cases were interviewed over the phone to complete the questionnaire. For the controls, a screening tool was used to identify symptom-free patients; the disease-specific BCTQ is considered a reliable and valid method of assessing patients and includes a symptom severity scale (SSS) and functional status scale (FSS).[20] We accepted those patients who scored 19 points and below, indicating that they were asymptomatic and met the inclusion criteria. Face-to-face interviews were performed.

Back translation was performed with the help of a translator, and the questionnaire was discussed among all data collectors, including the authors and well-qualified medical interns, to reach a consensus regarding how to ask and explain the questions.

A pilot study was conducted with 10 cases and 10 controls to test the face validity and to estimate the time needed for data collection.

The questionnaire is divided into two main sections. The first section pertains to demographic characteristics, including age, sex, nationality, marital status, level of education, employment status, dominant hand, smoking, height, weight, and presence of clinical conditions (DM, hypertension, hypothyroidism, and RA). The second section collected detailed information about smartphone use, such as the frequency, duration, hand preference, and purpose of use.

Ethics considerations

Participation in the study was voluntary, and participants could withdraw from the study at any time. The questionnaire was accompanied by a consent form that explained the purpose of the research and assured the participant of confidentiality. Data were anonymized and used for research purposes only. Ethical approval was obtained from the Institutional Review Board at King Saud University, Riyadh, Saudi Arabia (no. E-19-3714). All data used in the study are available for interested researchers upon request and approval from the first author.

Statistical analysis

Statistical analyses were performed using IBM-SPSS version 25.0. Descriptive statistics were calculated (frequencies, percentages, means, standard deviations and medians) to describe the categorical and numerical variables. The Chi-square test and Fisher's exact test were used to quantify the associations between categorical variables. Univariate and multivariate binary logistic regression was used to identify the independent variables related to the study outcome. A P value ≤ 0.05 and 95% confidence intervals are used to represent the statistical significance and precision of the results.

Results

Ninety-five (N = 95) cases and one hundred ninety controls (N = 190) participated in the study. Table 1 shows the participants' sociodemographic characteristics. Most of the sample population in both groups were female (84.2%) and Saudi (93%). The mean age was 34.6 +/– 10.2 years and 51.8 +/– 10.6 years in the controls and cases, respectively. It was found that the right hand was the dominant hand in more than 90% of both groups. In the control and case groups, 11.6% and 46.3% had DM, 9.5% and 38.9% had hypertension, 8.4% and 17.9% had hypothyroidism, and 4.2% and 3.2% had RA, respectively.

Table 2 demonstrates the patterns of smartphone use. The majority of participants (>95%) reported using smartphones for more than 5 days/week for more than 3 years. They used smartphones mostly for chatting (73.2% and 91.6% in the controls and cases, respectively), followed by web searching (73.7% in both) and reading (57.4% and 23.3%, respectively).

Table 3 illustrates the association between smartphone use and CTS. It was found that using smartphones for 2 hours/day or more was significantly associated with CTS, with an OR of 5.56 (P-value = 0.003; 95% CI 1.7–17.3).

In addition, it was found that holding the smartphone with two hands was associated with a 7.8 times higher odds of developing CTS than holding it with one hand (after adjusting for the number of hours of use/day).

Regarding the purpose for using the smartphone, it was found that using smartphones for chatting was associated with CTS, with an OR of 3.99 (P-value = 0.001; 95% CI 1.8–8.8). Other smartphone uses, such as playing games, taking photos, reading, and listening to music, had ORs <1 and statistically significant P values.

When adjusted for risk factors, including DM, hypertension, hypothyroidism and RA, the duration of hours of use remained significantly associated with CTS, as shown in Table 4.

Table 1: Sociodemographic characteristics of the study participants

Variable	Levels	Controls (n=190)		Cases (n=95)		Chi-square P
		n	%	n	%	
Sex	Male	30	15.8	15	15.8	1.000
	Female	160	84.2	80	84.2	
Marital status	Single	41	21.6	7	7.4	0.003
	Married	143	75.3	78	82.1	
	Divorced	4	2.1	6	6.3	
	Widowed	2	1.1	4	4.2	
Nationality	Saudi	177	93.2	89	93.7	0.867
	Non-Saudi	13	6.8	6	6.3	
Education level	Illiterate	2	1.1	8	8.4	0.000
	High school or less	55	28.9	48	50.5	
	Bachelor's degree	113	59.5	35	36.8	
	Postgraduate	20	10.5	4	4.2	
Employment status	Student	20	10.5	2	2.1	0.000
	Employed	70	36.8	25	26.3	
	Unemployed	93	48.9	52	54.7	
	Retired	7	3.7	16	16.8	
Smoking status	Smoker	9	75.0	3	25.0	0.532
	Non-smoker	181	66.3	92	33.7	
Body mass index (BMI; kg/m^2)	Normal (18-24)	57	30.3	9	9.5	0.000
	Overweight (25-29)	50	26.6	26	27.4	
	Obese (30 and higher)	81	43.1	60	63.2	

Discussion

In this study, the majority of the participants were female; this agrees with the literature, which has reported female sex to be a risk factor for developing CTS.[21,22] Women are two to three times more commonly affected by CTS than men.[23] Moreover, there was a difference in age between the groups: the mean age of the control group was 34.6 +/– 10.2 years, while that of the case group was 51.8 +/– 10.6 years. This finding is consistent with previous studies that found that CTS more commonly affects older adults.[6,24]

We found that using smartphones for 2 hours per day or more was significantly associated with the development of CTS. A cross-sectional study found that users who spent 5 hours or more using electronic devices had changes in the median nerve and the carpal tunnel that put them at a higher risk of developing CTS.[10] Moreover, in a study conducted among one hundred two students, it was found that the excessive use of smartphones can increase the size of the median nerve, which may increase the risk for developing CTS.[11]

While our results showed no significant association between the number of days or years of use and the incidence of CTS, this is most likely because the majority (>95%) of the participants in both groups used smartphones more than 5 days per week and had used them for more than 3 years.

Table 2: Patterns of smartphone use among the study participants

Pattern	Controls		Cases		Chi-square
Frequency of use	*n*=190	%	*n*=95	%	*P*
Per week					
1 day or less	0	0	1	1.1	0.037
2-3	0	0	3	3.2	
4-5	4	2.1	1	1.1	
>5 days	186	97.9	90	94.7	
Per day					
1 h or less	11	5.8	10	10.5	0
2-3 h	38	20	35	36.8	
4-5 h	56	29.5	32	33.7	
6-7 h	36	18.9	10	10.5	
8 h or more	49	25.8	8	8.4	
The duration of use					
1 year or less	0	0	1	1.1	0.563
2 years	2	1.1	0	0	
3 years or more	188	98.9	94	98.9	
Main purpose					
Typing/editing text	54	28.4	36	37.9	0.105
Chatting	139	73.2	87	91.6	0
Searching the web	140	73.7	70	73.7	1
Playing games	41	21.6	2	2.1	0
Taking photos	76	40	14	14.7	0
Watching movies	49	25.8	19	20	0.28
Reading	109	57.4	22	23.2	0
Listening to music/podcasts	51	26.8	4	4.2	0
Drawing/creating graphics	6	3.2	0	0	0.08

After adjusting for the risk factors (confounders), including DM, hypertension, hypothyroidism, and RA, we found that using a smartphone 4 hours or more per day was associated with developing CTS, with an OR of 4.5 (*P*-value = 0.001; 95% CI 1.81–11.54).

Furthermore, the results showed that hand preference was significantly associated with CTS (after adjusting for the number of hours of use/day). Those who held the smartphone with both hands had a 7.8 times higher odds of developing CTS than the participants who used one hand. In a small study that included 10 female participants who were asked to use smartphones for a specific period of time and then undergo EMG to assess muscle activity, the results showed high muscle activity and induced pain in one-handed participants, which is in contrast to our findings.[25] The purpose for using smartphones differed between participants, and chatting, searching the web, and reading were the most common purposes among our participants. We found that using a smartphone for chatting was associated with CTS, with an OR of 3.99. This might be explained by the prolonged duration of use rather than the function itself. One study showed that using a smartphone for 30 minutes while maintaining a comfortable sitting posture on a chair was associated with adverse effects on the wrist and that continued use induces muscle fatigue.[26]

The strength of our study is that it had an adequate sample size, and the sample population was representative. Moreover, to the best of our knowledge, no similar Saudi Arabian case-control study has been published. This study can increase awareness of the effects of smartphone use on the median nerve, especially among primary care physicians, who have an important role in diagnosing and managing this condition. They should be aware of the risk factors for future development of carpal tunnel syndrome. The limitations of our study include recall bias due to the self-reporting of screen time per day by the participants, as some participants did not know the exact number of hours spent using their smartphones. Moreover, prospective studies are needed to examine the long-term effects of smartphone use.

Conclusion

Smartphone use has increased over the past decade. Studies on this problem are limited, and its relation to the development of CTS, which can be a disabling condition for patients, is unclear. This study showed that 4 or more hours per day of smartphone use was associated with the development of CTS. Furthermore, holding a smartphone with both hands was associated with a 7.8 times higher odds of developing CTS than holding it with one hand. Further prospective studies are needed to examine the long-term effects of smartphone use on the median nerve.

Acknowledgements

The authors would like to gratefully acknowledge the input of Dr. Ahmed Moosa AlHadidi, Dr. Zainab Sami AlWatani and Dr. Safa Mohamed Ali for their contributions to data collection.

Table 3: Association between smartphone use and CTS

Factor	Levels	Controls		Cases		OR	*P*	95% CI	
		n=190	%	*n*=95	%			LB	UB
Average number of hours per day of smartphone use	1 h or less	11	52.40	10	47.60		0.001	Reference	
	2-3 h	38	52.10	35	47.90	5.568	0.003	1.787	17.352
	4-5 h	56	63.60	32	36.40	5.641	0.000	2.347	13.563
	6-7 h	36	78.30	10	21.70	3.5	0.005	1.475	8.308
	8 h or more	49	86.00	8	14.00	1.701	0.309	0.611	4.739
	5 days or less	4	2.1	5	5.3	2.583	0.151	0.677	9.853
Average number of days per week of smartphone use	>5 days	186	97.9	90	94.7	Reference			
Average number of years smartphone use	<3 years	2	1.1	1	1.1	1.000	1.000	0.090	11.170
	3 years or more	188	98.9	94	98.9	Reference			
Number of hands used to hold the smartphone*	One hand	135	71.10	57	60.00	Reference			
	Two hands	55	28.90	38	50.00	7.766	0.001	2.431	24.811
Main purpose for smartphone use									
Typing/editing text	No	136	71.6	59	62.1	Reference			
	Yes	54	28.4	36	37.9	1.537	0.106	0.913	2.587
Chatting	No	51	26.8	8	8.4	Reference			
	Yes	139	73.2	87	91.6	3.99	0.001	1.807	8.81
Searching the web	No	50	26.3	25	26.3	Reference			
	Yes	140	73.7	70	73.7	1	1	0.572	1.749
Playing games	No	149	78.4	93	97.9	Reference			
	Yes	41	21.6	2	2.1	0.078	0.001	0.018	0.331
Taking photos	No	114	60.0	81	85.3	Reference			
	Yes	76	40.0	14	14.7	0.259	0.000	0.137	0.49
Watching movies	No	141	74.2	76	80.0	Reference			
	Yes	49	25.8	19	20.0	0.719	0.281	0.395	1.309
Reading	No	81	42.6	73	76.8	Reference			
	Yes	109	57.4	22	23.2	0.224	0.000	0.128	0.391
Listening to music/podcasts	No	139	73.2	91	95.8	Reference			
	Yes	51	26.8	4	4.2	0.12	0.000	0.042	0.343
Drawing/creating graphics	No	184	96.8	95	100.0	Reference			
	Yes	6	3.2	0	0.0	0	0.999	0	

*Adjusted for number of hours of use/day

Table 4: Association between smartphone use and CTS after adjustment for risk factors

Factor	Level	Controls		Cases		OR	OR *P*	OR 95% CI	
		n=190	%	*n*=95	%			LB	UB
Average number of hours per day of smartphone use	1 h or less	11	52.40	10	47.60		0.015	Reference	
	2-3 h	38	52.10	35	47.90	2.753	0.081	0.874	10.332
	4-5 h	56	63.60	32	36.40	4.530	0.001	1.815	11.542
	6-7 h	36	78.30	10	21.70	2.812	0.025	1.135	6.893
	8 h or more	49	86.00	8	14.00	1.634	0.371	0.562	4.687
Average number of days per week of smartphone use	5 days or less	4	2.10	5	5.30	1.416	0.686	0.262	7.658
	>5 days	186	97.90	90	94.70	Reference			
Average number of years smartphone use	<3 years	2	1.10	1	1.10	0.769	0.856	0.045	13.029
	3 years or more	188	98.90	94	98.90	Reference			

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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