

The relationship between carpal tunnel syndrome, smartphone use, and addiction: A cross-sectional study

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ABSTRACT

Objectives: This study aims to investigate the use of and addiction to smartphones in individuals with and without carpal tunnel syndrome (CTS).

Patients and methods: The cross-sectional study included a total of 404 participants (286 females, 118 males; mean age: 39.7±11.6 years; range, 16 to 75 years) who applied to the Neurology Department of the Fırat University Faculty of Medicine, between April 2019 and October 2019. The participants were divided into two groups: 202 patients diagnosed with CTS were included in the case group, and 202 patients and their relatives who did not have hand and wrist complaints were included in the control group. The diagnosis of CTS was made by evaluating the history, physical examination, and electromyography findings. Data were collected with participant information forms and the Smartphone Addiction Scale.

Results: It was found that the risk of CTS increased 1.022 times with a one-unit increase in the SAS score and 1.292 times with a 1-h increase in daily smartphone use.

Conclusion: Smartphone addiction can be considered as a potential risk factor for CTS; however, the effect of smartphone addiction on CTS severity was not examined in this study. The relationship between disease severity, smartphone use, and smartphone addiction in CTS patients requires further investigation to provide clarification on this issue.

Keywords: Electromyography, median nerve, neuropathy, smartphone addiction.

Carpal tunnel syndrome (CTS), the most common entrapment neuropathy, is a chronic focal compressive neuropathy caused by the compression of the median nerve at the level of the carpal tunnel in the wrist.^[1] Carpal tunnel syndrome prevalence estimates vary widely in the literature in accordance with the diagnostic method and tool used^[2] and range from 2.7 to 4.9%.^[3] Although it is more common in females and between the ages of 40 and 60, it can affect people of all ages.^[4] Carpal tunnel syndrome is usually idiopathic;^[5] nevertheless, conditions such as obesity, pregnancy, arthritis, hypothyroidism, diabetes

mellitus, trauma, and mass lesions may also play a role in the etiology.^[6] Frequently repetitive hand/wrist flexion and extension movements may increase the pressure in the carpal tunnel and cause CTS with median nerve damage. It is typically characterized by pain, tingling, numbness, or hypoesthesia in the hand and fingers.^[5] The diagnosis of CTS can be easily made by history, physical examination, and electromyography (EMG).^[7]

Smartphone use is rapidly increasing,^[8] and the number of smartphone users worldwide has exceeded six billion in 2020.^[9] According to Newzoo's 2021

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Global Mobile Market Report, there were 52.06 million smartphone users in Turkey in 2020.^[10] According to the data of Statista regarding the daily time spent on smartphones worldwide, almost half of the participants spent 5 h or more on their smartphones daily.^[11] Excessive and problematic use of smartphones is associated with smartphone addiction.^[12] Smartphone addiction is a public health problem that affects a significant and increasing number of people and causes serious psychological, social, and physical problems in their lives.^[13]

Repetitive hand movements caused by the frequent use of smartphones reduce the area around the median nerve, causing an increase in carpal tunnel pressure.^[14] As a result, a significant decrease in sensory nerve conduction velocity, which is a well-known early parameter of CTS, is an indicator that excessive smartphone use affects the median nerve.^[15]

Although there are cross-sectional and experimental studies examining the relationship between smartphone use, smartphone addiction, and CTS,^[14-20] no case control study exists in the literature. To the best of our knowledge, this is the first study investigating smartphone use and addiction in CTS case and control groups. The aim of this study was to investigate the use of and addiction to smartphones in individuals with and without CTS, who applied to the Firat University Hospital, Department of Neurology.

PATIENTS AND METHODS

The cross-sectional study included a total of 404 participants (286 females, 118 males; mean age: 39.7±11.6 years; range, 16 to 75 years) who applied to the Neurology Department of the Firat University Faculty of Medicine, between April 2019 and October 2019. Participation was voluntary, and all participants were smartphone users. The participants were separated into two groups: the case group consisted of 202 patients diagnosed with CTS, and the control group included 202 patients and their relatives who did not have hand and wrist complaints and applied for another reason. Case and control groups were matched according to sex and age ($p>0.05$), and the case control ratio was 1:1. Carpal tunnel syndrome was suspected when pain, paresthesia (numbness and tingling), or weakness was present in the median nerve region, as in the first three fingers and the radial half of the fourth finger, and symptoms worsened with exercise and at night while lying down. The patients were clinically evaluated by performing the Phalen

maneuver and Tinel's test, along with sensory and strength examination. Both upper extremity median, ulnar, and radial nerve motor and sensory conduction of the patients were electrophysiologically evaluated. The diagnosis of CTS was made by evaluating the clinical and electrophysiological findings. In our study, among the patients with physical examination findings with positive Phalen maneuver and Tinel's test, those with normal electrophysiological examination were considered mild CTS, those with normal motor conduction and sensory involvement were considered moderate CTS, and those with motor involvement were considered severe CTS.^[21] Patients diagnosed with severe CTS (with motor involvement or weakness) were not included in the study, considering that their phone use may be limited and this situation may mislead the study result. Additionally, those with a diseases that may play a role in the etiology of CTS (diabetes mellitus, hypothyroidism, rheumatoid arthritis, osteoarthritis, obesity), pregnant women, and those with a history of former hand or wrist fracture, trauma, injuries, or surgery were not included in the case group.

The dependent variable was taken as being in the case or control group. Independent variables were sex (male/female), age (year), occupation (occupation with intense hand use/occupation without intense hand use), smoking status (smoking/not smoking), duration of smoking (years), Smartphone Addiction Scale (SAS) score, daily smartphone usage (h/day), and years of smartphone use. Symptoms were questioned with the following question: "Do you have hand/wrist complaints such as pain, numbness, and tingling?" Those who answered "Yes" were accepted as those with symptoms. Those who answered "No" were regarded as those without symptoms.

Occupations are categorized under 10 main groups in the Turkish Occupations Dictionary prepared by the Turkish Employment Agency^[22] based on the International Standard Classification of Occupations (ISCO-08) created by the International Labor Organization.^[23] These main groups were divided into two groups by Lam and Thurston,^[24] namely manual work and clerical work. In the present study, the occupation was questioned with the following open-ended question: "What is your occupation?" The answers to this question were first classified into 10 groups by using these classifications, then these 10 groups were combined to form two different groups, and the categories "occupation with intense hand use" and "occupation without intense hand use" were created.

A survey developed by the researchers was used as a data collection tool in the study. The survey was administered face-to-face to all participants after making the necessary explanations and obtaining informed consent. The survey consisted of two parts. The first part consisted of the participant information form, and in the second part, the SAS was used.

Smartphone Addiction Scale is a 33-item, 6-point, Likert-type personal rating scale developed by Kwon et al.^[25] Options at this scale range from 1 (strongly disagree) to 6 (strongly agree). The total score that can be obtained from the scale can range from 33 to 198. Higher scores indicate a higher risk of smartphone addiction. The scale does not have a specific cut point. The Cronbach alpha value of the original scale is 0.967. The validity and reliability study of the Turkish version of the scale was conducted by Demirci et al.^[26] The Turkish version of the scale consists of seven factors, the variance explained is 66.4%, and the Cronbach alpha value is 0.947.

Electrophysiological examination was performed using a three-channel electromyography machine (Dantec Keypoint® software version 5.13; ALPINE BioMed, San Carlos, CA, USA). Each participant was tested in a supine position at 26°C in a quiet, air-conditioned room. The temperature of each hand was kept at 34–36°C. Stimulations were made using standard stimulator electrodes. The supramaximal stimulation technique was used. For the measurement of the distal motor latencies of the median and ulnar nerves, the stimulating electrode was placed on the wrist, and the recording electrodes (disc electrode) were placed on the abductor pollicis brevis and adductor digiti minimi muscles, respectively, 8 cm away from the stimulating electrode. This measurement was made orthodromically. For sensory nerve conduction examination of the median and ulnar nerves, the stimulating electrode was placed on the wrist, and the recording electrodes (ring electrodes) were placed on the first and fifth fingers, keeping a standard distance of 14 cm from the stimulating electrode. This measurement was made antidromically. In the electrophysiological examination, normal reference values were set as <3.8 ms for median nerve motor distal latency, >50 m/s for median nerve sensory conduction velocity, <3.6 ms for ulnar nerve motor distal latency, and >50 m/s for ulnar nerve sensory conduction velocity. A diagnosis of CTS was made with the detection of prolonged motor distal latency and/or slowdown in sensory conduction velocity in median nerve examination and normal evaluation of ulnar nerve examination.

The number of people to be included in the study (case group) was calculated as 202 from the $n=t^2pq/d^2$ formula used when the number of individuals in the universe was unknown.^[27] In the formula, “t” is the theoretical value found from the t table at a certain degree of freedom and detected error level ($t=1.96$); “p” is the probability of occurrence of the examined event ($p=0.05$);^[3] “q” is the probability of the examined event not occurring ($q=0.95$); “d” is the deviation from the frequency of occurrence of the event ($d=0.03$).

Statistical analysis

The data obtained in the study were recorded and analyzed using the IBM SPSS version 21.0 software (IBM Corp., Armonk, NY, USA). Means were given with mean \pm standard deviation (SD), and medians were presented with the 1st quarter and 3rd quarter (median [Q1-Q3]). Chi-square test was used to compare case and control groups according to categorical variables (sex, occupation, and smoking status). The Kolmogorov-Smirnov test was used to determine whether the continuous variables were normally distributed. T-test was used for the comparisons of case and control groups concerning normally distributed continuous variables (age, SAS score). Mann-Whitney U test was used for the comparisons of case and control groups involving non-normally distributed continuous variables (duration of smoking [years], daily smartphone usage [h/day], and smartphone usage [years]). Binary logistic regression analysis was performed with the independent variables that were significant in bivariate analyses and the dependent variable, which is whether CTS was present. Statistical significance was set at $p<0.05$.

RESULTS

All participants in the CTS case group had hand/wrist symptoms, and the mean duration of symptoms was 2.4 ± 2.7 years (range, 0.08 to 15 years; median: 2 years). Characteristics of all participants, both case and control groups, are presented in Table 1. There was no difference between the case and control groups in terms of sex, age, occupation, smoking status, duration of smoking, and years of smartphone use ($p>0.05$). However, SAS score and daily smartphone usage were significantly higher in the case group than in the control group ($p<0.05$).

Table 2 demonstrates the results of binary logistic regression analysis predicting the risk of CTS. According to binary logistic regression analysis results using a single independent variable, the risk of CTS increased 1.022 times with a one-unit increase

TABLE 1
Comparison of characteristics between case and control groups

Variables	All participants				CTS case group				Control group				p			
	n	%	Mean±SD	Median	Q1-Q3	n	%	Mean±SD	Median	Q1-Q3	n	%		Mean±SD	Median	Q1-Q3
Age (year)			39.7±11.6					39.1±10.7					40.3±12.5			0.300 ^b
Sex																0.189 ^a
Male	118	29.21			53	44.92					65	55.08				
Female	286	70.79			149	52.10					137	47.90				
Occupation																0.647 ^a
Occupation with intense hand use	302	74.75			153	50.66					149	49.34				
Occupation without intense hand use	102	25.25			49	48.04					53	51.96				
Smoking status																0.507 ^a
Smoking	114	28.22			60	52.63					54	47.37				
Not smoking	290	71.78			142	48.97					148	51.03				
Duration of smoking (years)			15.0	10.0-20.0			15.0	10.0-20.0					19.0	11.0-20.0		0.073 ^c
SAS score			83.7±20.9				88.1±24.1						79.3±16.1			<0.001 ^b
Daily smartphone usage time (h/day)			2.0	1.0-3.5			2.0	1.0-4.0					1.5	1.0-3.0		<0.001 ^c
Smartphone usage (years)			5.0	4.0-8.0			5.0	4.0-9.0					5.25	4.0-8.0		0.204 ^c

SD: Standard deviation; Q: Quartile; SAS: Smartphone Addiction Scale; a: p value of Chi-square test; b: p value of t test; c: p value of Mann Whitney U test.

TABLE 2
Odds ratios and 95% confidence intervals of binary logistic regression analysis using participant characteristics as predictors for the risk of CTS

Variables	Unadjusted			Adjusted*		
	OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>
SAS score	1.022	1.011-1.032	<0.001	1.013	1.002-1.024	0.025
Daily smartphone usage time (h/day)	1.292	1.164-1.434	<0.001	1.229	1.100-1.374	0.001

CTS: Carpal tunnel syndrome; OR: Odds ratio; CI: Confidence interval; SAS: Smartphone Addiction Scale; * Model $\chi^2=33.770$ $p<0.001$; Nagelkerke $R^2=0.107$, Hosmer and Lemeshow test $p=0.370$.

in the SAS score ($p<0.001$) and 1.292 times with a 1-h increase in daily smartphone usage ($p<0.001$). Afterward, the binary logistic regression analysis was performed with the model created using the independent variables of the SAS score and daily smartphone usage. Both independent variables remained significant in the model. The chi-square value of the model was 33.770, which was found to be significant ($p<0.001$).

DISCUSSION

Studies examining the effect of smartphone use and addiction on the median nerve and flexor pollicis longus tendon have been conducted with healthy people.^[14-19] In a cross-sectional study, the use of electronic devices, including smartphones, was examined in people with CTS symptoms, and it was emphasized that conducting case-control studies or prospective studies with nerve conduction testing was valuable.^[20] The current study, to the best of our knowledge, is the first study comparing smartphone use and addiction in CTS case and control groups in the literature. In the present study, it was found that smartphone addiction and prolonged daily smartphone use increase the risk of CTS.

Smartphone addiction is generally studied with samples of adolescents or university students.^[28] The fact that the present study included a sample with a mean age of 39.7 ± 11.6 and that the SAS score was similar to the studies conducted with university students^[12,29,30] indicates that smartphone addiction is an issue not only in young individuals but also in adults.^[31]

In a cross-sectional study conducted in healthy adults, the median nerve sensory and motor conduction velocity was found to be lower, and the latency was higher in electrophysiological examination in the group with a high level of

smartphone addiction compared to the group with a lower level of smartphone addiction.^[15] Similarly, in the current study, the SAS score in the case group was found to be significantly higher compared to the control group (Table 1). In addition, it was found that the increase in SAS scores increased the risk of CTS (Table 2). Similarly, in another cross-sectional study conducted on healthy adults, a significant positive correlation was found between the SAS score and the severity of hand pain.^[16]

In a study examining the relationship between smartphone use and CTS physical examination findings, it was reported that positivity in Phalen's and reverse Phalen's tests were associated with the duration of daily smartphone use (h) and the duration of continuous smartphone use (min).^[17] These findings support those of the present study in that daily smartphone usage (h/day) was found to be significantly higher in the CTS case group than in the control group (Table 1). In bivariate analyses, although there was a significant difference between CTS case and control groups according to daily smartphone usage (h/day), there was no significant difference between groups according to years of smartphone use (Table 1). This suggests that the main feature of smartphone use making it a CTS risk factor is the dependent repetition of daily excessive usage periods rather than the year of use. Indeed, frequent hand/wrist movements can cause CTS.^[5]

This study has some limitations. First, obtaining information about the smartphone usage characteristics (years of smartphone use, daily smartphone usage, smartphone addiction level) of the participants through a self-reported survey instead of an objective measurement tool may cause recall bias. Second, the findings of this study cannot be generalized to the community as this study is hospital-based, and the probability of the admission to the hospital for those exposed to a certain factor

is different from those who were not exposed to this factor (Berkson's bias). Nevertheless, the fact that the sample size was calculated in this study and the larger sample size compared to similar studies are strong aspects of this study.

In conclusion, the increase in smartphone addiction and daily smartphone usage increases the risk of CTS. Daily smartphone usage was more important than the years of smartphone usage as a CTS risk factor. Smartphone addiction can be considered a potential risk factor for CTS. Investigation of the relationship between disease severity and smartphone use and addiction in CTS patients in future studies can provide more clarification on this issue. Since the use of smartphones negatively affects the hand/wrist health of individuals, smartphone manufacturers need to consider the ergonomic features in their design.

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Ethics Committee Approval: The study protocol was approved by the Firat University Non-Invasive Research Ethics Committee (date: 02.04.2019, no: 320945). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from the participants.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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