



ARAŞTIRMA / RESEARCH

The effect of smartphone usage on the median nerve

Akıllı telefon kullanımının median sinir üzerine etkisi

Faik İlik¹, Hüseyin Büyükgöl², Fatma A. Eren³, Mustafa K. İlik⁴, Fatih Kayhan⁵, Hatice Köse⁶

¹Baskent University, Konya Hospital, Department of Neurology, Konya, Turkey

²KTO Karatay University, Medicana Hospital, Department of Neurology, Konya, Turkey

³Aksaray State Hospital, Department of Neurology, Aksaray, Turkey

⁴Farabi Hospital, Department of Neurosurgery, Konya, Turkey

⁵Self-employed

⁶Trakya University, Department of Neurology, Edirne, Turkey

Cukurova Medical Journal 2018;43(1):67-72.

Abstract

Purpose: The aim of this study was to examine the effects of smartphone use on the median nerve.

Materials and Methods: Participants were classified into three groups according to their smartphone use frequencies; high smartphone users (with Smartphone addiction scale (SAS) score of higher than 71), low smartphone users (SAS score less than 71) and classical type mobile phones users. The Visual analogue scale (VAS), quick-disabilities of arm, shoulder, hand (qDASH) and median nerve conductions of the participants were assessed. Groups were compared to each other as well as dominant and non-dominant hand nerve measurements of participants were also compared.

Results: VAS and qDASH values were not significantly different between groups. It was observed that the rare use of smartphones affected the median nerve conductions in a lesser manner compared to the classical mobile phone use. However, using smart phone in an increasing rate influenced the median nerves adversely.

Conclusion: Excessive use of smartphone can lead to carpal tunnel syndrome via affecting the median nerve. In recent decades, there has been a widespread use of smartphones even at the level of addiction. This should be noted while designing the smartphones and voice applications should be used more often. Furthermore, it can be beneficial to follow up the median nerve conductions of patients who are addicted to smartphones with the help of electrophysiological studies.

Key words: Smartphone, median nerve, carpal tunnel syndrome

Öz

Amaç: Bu çalışmada akıllı telefon kullanımının median sinir üzerine etkisinin değerlendirilmesi amaçlanmıştır.

Gereç ve Yöntem: Katılımcılar akıllı telefon kullanımı fazla olanlar (Akıllı telefon bağımlılık ölçeği (SAS) skoru 71 üzerinde olanlar), az kullanımı olanlar (71'nin altındakiler) ve klasik cep telefonu kullananlar olarak 3 gruba ayrılarak değerlendirildi. Katılımcıların görsel analog skala (VAS), kol, omuz ve elin hızlı yetersizlikleri (qDASH) değerleri ve median sinir iletileri değerlendirildi.

Bulgular: Akıllı telefonu az kullanan grupta diğer 2 gruba göre anlamlı derecede median sinir latanslarının daha kısa ve hızlarının yüksek olduğu gözlemlendi. Ancak, akıllı telefonu fazla kullananlar ile klasik cep telefonu kullananlar arasında median sinir iletileri açısından anlamlı fark gözlemlenmedi. VAS ve qDASH değerlerinde gruplar arasında anlamlı fark gözlemlenmedi.

Sonuç: Aşırı akıllı telefon kullanımı karpal tünel sendromu ve buna bağlı median sinirin etkilenmesine neden olabilir. Akıllı telefonların yaygınlaştığı hatta bağımlılık düzeyinde kullanımının olduğu günümüzde telefon tasarımlarında bu durumlar akılda tutulmalı belki de sesli komut uygulamalarında daha çok yer verilmelidir. Ayrıca akıllı telefon bağımlılığı olan hastalarda median sinir iletilerinin elektrofizyolojik olarak takip edilmesi faydalı olabilir.

Anahtar kelimeler: Akıllı telefon, median sinir, karpal tünel sendromu

Yazışma Adresi/Address for Correspondence: Dr. Faik İlik, Baskent University, Konya Hospital, Department of Neurology, Konya, Turkey E-mail: faikilik@hotmail.com

Geliş tarihi/Received: 22.01.2017 Kabul tarihi/Accepted: 11.03.2017

INTRODUCTION

The importance and popularity of smartphones can be understood when we evaluate their sales volume. Now, more than 1.5 billion individuals use smart phones throughout the world. It can be estimated that there will be more than a billion sales of smartphones in 2016. The main reason for this is that smartphones have different applications and their internet access that basic mobile phone do not have¹. It is a reality that smartphones assist patients and their doctors with the help of health applications². However, in recent years, 'smartphone addiction' concept has been emerged since smartphone use has become quite prevalent. It has been observed that the smartphone addiction is approximately 8.4%³. The median nerve could be the main responsible nerve for the muscle movements while using smartphones. Motor branch of the median nerve moves to the distal of the palm and it innervates into the 1st and 2nd lumbrical muscles. Furthermore, recurrent motor branch innervates the superficial head of thenar muscles such as opponens pollicis, abductor pollicis brevis, and flexor pollicis brevis⁴. Various reasons; particularly frequent repetitive movements can lead to carpal tunnel syndrome (CTS) via median nerve damage⁵. Electroneuromyography (ENMG) is the most important examination tool which can be used to examine the functional status of median nerve as other peripheral nerves⁶. Using smartphone is easier than basic cell phones, but their usage time is also increased. The aim of this study is to evaluate the effects of smartphone usage on the median nerve function.

MATERIALS AND METHODS

In this study, the sampling group was composed of healthy 40 smartphone users and 22 basic mobile phone users (totally 62 individuals). The study was approved by the local ethics committee of University (Date: 01/09/2015, Number: 26857650/159). An informed consent form was obtained from all participants. Participants who were using their phones at least one year were sequentially included in the study. Individuals who had systemic disease history (6 participants), peripheral nerve disease (1 participant), who were diagnosed with entrapment neuropathy (2 participants) and who were smoking (19 participants) due to unfavorable effects on the nerve

conduction were excluded from the study. Participants were divided into three groups; according to their phone usage rates.

Scales

Smartphone addiction scale (SAS): The use of smartphone was assessed by using SAS. SAS is a scale that is composed of 33 questions and participants gave 1 to 6 scores to each question⁷. Turkish validity and reliability studies were conducted by Demirci K and friends⁸. High scores represent excessive smartphone usage. In this study, SAS mean scores of smartphone users was 71. It was determined that participants who had SAS scores higher than 71 were grouped as 'High smartphone users'. On the other hand, participants who had SAS scores less than 71 were grouped as 'Low smartphone users'.

Quick-disabilities of arm, shoulder, hand (qDASH): In order to evaluate the upper extremity functions and symptoms, qDASH survey was applied to participants. Out of 11, at least 10 of the titles should be answered in order to calculate the qDASH scores. Each title contained 5 options of answers and score of the scale was calculated by using scores of these titles (0: there is no disability and 100: there is a severe disability)⁹. Turkish validity and reliability studies were conducted by Koldas Dogan S and friends¹⁰. The qDASH scores of three groups of patients were compared to each other.

Visual analogue scale (VAS): Participants were also assessed by using VAS. VAS was used to convert some of the values that cannot be measured quantitatively. The definition of the parameter was written in two ends of a 10 cm line and the patient was asked to mark the appropriate point on the line where she/he thought her/his situation suited. For instance, in order to measure the 'pain', it was written 'I do not have pain' on one end of the line and 'I have severe pain' was on the other end of the line¹¹. The patient was supposed to mark the line according to her/his health status. All the scales were filled out by the participants and evaluated by a neurologist.

Nerve conduction studies

Electrophysiological examination was performed by using Micromed SpA device (07). Researchers were careful to keep the temperature of patients' skins to

be higher than 310C during the study. Ag/AgCl electrodes were used in the study. Nerve conduction studies were carried out in the carpal tunnel protocol. Median nerve sensory and motor nerve conduction studies were evaluated¹². Orthodromic method was used in all of the nerve conduction studies. Recordings were done from the wrists by giving stimulus in the median nerve sensory conduction study. Recording electrodes were located in the thenar region in the median nerve motor conduction study. Distal latency was determined with the help of stimulus from the wrist. Nerve conduction studies were carried out in the same electrophysiological laboratory and they performed by a single neurologist using the standard methods.

Statistical analysis

Statistics: 22.0 Windows version of SPSS (Statistical Package for the Social Sciences) program was used in order to perform the statistical analyses. $n = N \cdot t^2 pq / d^2 (N-1) + t^2 pq$ formulation was used to calculate sample size of the study. Patients who were using smartphones were divided into two groups according to their SAS scores, the ones with mean SAS scores less or higher than 71. The other group was determined as basic mobile phone users. In order to assess whether the data were normally distributed, Kolmogorov Smirnov test was applied.

Chi-square test was used to analyze the categorical variables. Kruskal Wallis and Mann Whitney U tests were used in order to compare the values related to nerve conduction velocity of groups. The numerical values of dominant and non-dominant hand nerve conduction between groups were assessed by using

Wilcoxon Signed Ranks test. 'p' values of <0.05 were considered significant for all the variables.

RESULTS

Totally 62 participants were included in the study. The 37 of the participants (57.9%) were female and 25 of them (40.3%) were male. The 22 (35.5%) of the participants were using basic mobil phones. The SAS median value of 19 of the participants (30.6%) was lower than 71. However, the mean SAS value of 21 participants (33.9%) was higher than 71. There was no difference between groups in terms of age and gender ($p=0.55$ and $p=0.35$; respectively). There was also no significant difference between groups in terms of their VAS scores ($p=0.15$) as well as their qDASH scores ($p=0.30$) (Table 1). All of the participants were using their phones with their dominant hands. When the dominant hand nerve sensory conduction and sensory latencies were compared, there was a significant difference between groups ($p=0.00$ and 0.00 ; respectively). The median nerve sensory conduction was significantly faster and sensory latency was significantly shorter in low smartphone users compared to others ($p=0.00$ and 0.00 ; respectively). However, there was no difference between the groups of basic mobil phone users and high smartphone users ($p=0.10$ and 0.54 ; respectively). On the other hand, low smartphone users had significantly shorter median nerve motor latency and faster motor conduction compared to others ($p=0.00$, $p=0.01$). Besides, no difference was observed between basic mobil phone users and high smartphone users ($p=0.54$ and $p=0.07$; respectively).

Table 1. Demographic and electrophysiological datas of participants

	Basic mobile phone users (n=22)	Low smartphone users (n=19)	High smartphoneusers (n=22)	P
VAS pain (cm)	2.95 ± 2.01	2.15± 2.16	2.90 ±1.92	0.15
Q-dash score	16.63 ± 13.92	13.26± 10.74	19.80± 12.74	0.30
MN SCV	52.91 ± 4.69	60.62 ± 4.42	50.77± 9.24	0.00
MN SL	2.74 ± 0.37	2.28 ± 0.22	3.01± 0.62	0.00
MN MCV	54.38 ± 6.42	58.24± 3,53	51.93±6.32	0.03
MN ML	3.31±0.41	2.90± 0,34	3.55±0.55	0.00

Datas are mean±standard deviation. P-values are from analysis of Kruskal–Wallis tests. VAS, visual analog scale; Q-dash, Quick-Disabilities of Arm, Shoulder, Hand score; MN, median nerve; SCV, sensory conduction velocity; SL, sensory latency; MCV, motor conduction velocity; ML, motor latency

When we compared the difference between the dominant and non-dominant hands of basic mobil phone users, there was a significant difference between median sensory nerve conduction velocity

and sensory latency as well as motor conduction velocity and motor latencies according to others (p values=0.03, 0.02, 0.01, 0.00; respectively). In this group, there was a significant increase in the latency

values as well as deceleration in the conduction velocities of dominant hand compared to non-dominant hand (Table 2).

There was no significant difference between median sensory nerve conduction velocity, sensory latency, motor conduction velocity and motor latencies of low smartphone users when we examined the difference between the dominant and non-dominant hands of them (p values= 0.74, 0.22, 0.77, 0.07; respectively).

There was a significant difference between high smartphone users and basic mobil phone users in terms of dominant hand and non-dominant hand sensory nerve conduction velocity, latency sensory and motor conduction velocity (p values= 0.00, 0.00, 0.00; respectively). Furthermore, mild carpal tunnel syndrome was observed in 2 of the participants. One was in high smartphone users group and other was in basic mobile phone users group.

Table 2. Comparison of dominant and non-dominant hand electrophysiological findings

	Dominant-side	Non-dominant side	<i>P</i>
Basic mobile phone users (n=22)			
MN SCV	52.91±4.69	56.78±5.38	0.03
MN SL	2.74±0.37	2.43±0.25	0.02
MN MCV	54.38±6.42	58.00±4.59	0.01
MN ML	3.31±0.41	3.02±0.43	0.00
Low smartphone users (n=19)			
MN SCV	60.62±4.42	60.01±6.28	0.74
MN SL	2.28±.22	2.24±.22	0.22
MN MCV	58.24±3.53	58.61±5.40	0.77
MN ML	2.90±.34	3.06±.36	0.07
High smartphone users (n=22)			
MN SCV	50.77± 9.24	57.01± 6.37	0.00
MN SL	3.01±.62	2.43±.25	0.00
MN MCV	51.93±6.32	59.04±4.23	0.00
MN ML	3.55±.55	3.23±.47	0.06

Datas are mean±standard deviation. P-values are from analysis of Mann-Whitney U test. MN, median nerve; SCV, sensory conduction velocity; SL, sensory latency; MCV, motor conduction velocity; ML, motor latency

DISCUSSION

In our study; median nerve sensory, motor conduction velocity, and differences in latencies were examined. It was observed that smartphone usage rarely influenced median nerves according to the basic mobil phone usage. However, median nerves were adversely affected by the increasing use of smartphones.

The smartphone use has been significantly increased in recent years. Furthermore, this increase will continue according to estimations¹. In a study conducted in 2002, it was observed that the smartphone usage rate was 79%¹³. After just one year, it was indicated in another study that 72% of the individuals who were between the ages of 12 and 19 were using smartphones. Findings showed that the use of smartphone increased in time and its use was prominently high even among young

individuals¹⁴. Various health applications have also been increasingly used with the increasing numbers of smartphone usage. It has been aimed to support healthy individuals in order to maintain their current health status¹⁵. In case of patients with chronic diseases, the aim of some health applications is to give the opportunity to manage their disease appropriately and easily¹⁶. In recent years, studies have also been performed about hazardous effects of the smartphone usage. According to one of these studies, it has been stated that depression, anxiety and accordingly sleeping problems can be observed in individuals who are frequently using smartphones in their daily life¹⁷.

One of the important points in the smartphone usage is that these tools are used by continuous hand gestures. It has been observed that De Quervain's tenosynovitis occurs more often in smartphone users who write more than 50 text

messages in a day. There is a positive correlation between the pain in the thumb and writing text messages¹⁸. Furthermore, as a result of using a smartphone application which is for sending and receiving text messages, diagnosed bilateral extensor pollicis longus tendinitis disease has also been named as *whatsAppitis*¹⁹. In another recent study, median nerve areas were measured by ultrasonography because of the idea that frequent usage of smartphones can affect the median nerves of people. Median nerve is enlarged in people who frequently use smartphones and it has been also specified that this can be associated with CTS²⁰. As it is well known, the most important technique is ENMG in the examination of the functional status of peripheral nerves⁶. CTS occur as a result of trapping the median nerve in the level of wrist and ENMG is again the most important examination tool in order to both diagnose and classify this disease. Decrease in the sensory conduction velocity of the nerve is the earliest electrophysiological abnormality that can be observed in CTS²¹⁻²². In our study, sensory nerve conduction velocity, latency sensory, motor conduction velocity, motor latencies of participants were examined and the electrophysiological status of the affected nerves was also determined. VAS and qDASH scores of participants were compared to each other. According to our findings, as similar to others²⁰, there was no significant relationship between the habit of smartphone use and VAS as well as qDASH values of users. There was a significant decrease in the median nerve sensory conduction velocity according to the electrophysiological examination in low smartphone users compared to others. However, there was no difference between the classical cell phone users and high smartphone users. According to the examinations of dominant hand median nerve motor latencies and motor conduction velocities of groups, it was observed that the conduction was faster and latencies were lower in low smartphone users compared to others. It has been specified that repetitive wrist extension and flexion movement, also the extension style finger movements can increase the pressure in the carpal tunnel²³⁻²⁴. The observation of the significant decrease in the sensory nerve conduction velocity due to the frequent use of smartphones, which is a well known early parameter of CTS, let us think that the repetitive hand movements due to the frequent use of smartphones can lead to increase the pressure in the carpal tunnel. Another important point is that

median nerve of basic mobil phone users are also deteriorated as median nerves of high smartphone users. The reason for this can be the difficulty of use the classical cell phones compared to smartphones due to their key structures.

There are some limitations in our study such as limited numbers of participants. Furthermore, all of the participants, included in our study were using cell phone. Patients who were not using cell phones in the current age range could not be formed. Since SAS scale was developed in order to measure only the frequency of smartphone use but not the basic mobil phone use, we could not determine how often classical cell phones were used.

Conclusively, frequent usage of smartphones can lead to CTS by adversely affecting the median nerves. Another important point is that smartphone usage has less influence on median nerve conduction compared to the basic mobil phone usage. The possible reason for that can be the ease of the smartphone use. There has been a widespread use of smartphones even at the level of addiction in recent decades and these smartphones should be appropriately designed and voice applications should be used more often. Besides, it can be beneficial to control median nerve conduction of patients who are addicted to smartphones in terms of electrophysiological features of their median nerves.

REFERENCES

1. International Data Corporation (IDC) (2013). Third quarter report 2013. Retrieved from <http://www.idc.com/getdoc.jsp?containerId=prUS24418013>.
2. Rad MZ, Ghuchani SR, Bahaadinbeigy K, Khalilzadeh MM. Real time recognition of heart attack in a smartphone. *Acta Inform Med*. 2015;23:151-4.
3. South Korea National Information Society Agency. Internet Addiction Survey 2011. Seoul, National Information Society Agency, 2011.
4. Ghasemi-Rad M, Nosair E, Vegh A, Mohammadi A, Akkad A, Lesha E et al. A handy review of carpal tunnel syndrome: from anatomy to diagnosis and treatment. *World J Radiol*. 2014;6:284-300.
5. Chammas M, Boretto J, Burmann LM, Ramos RM, Dos Santos Neto FC, Silva JB. Carpal tunnel syndrome - Part I (anatomy, physiology, etiology and diagnosis). *Rev Bras*. 2014;49:429-36.
6. Aksekili MA, Biçici V, Işık Ç, Aksekili H, Uğurlu M, Akkurt A et al. Comparison of early postoperative

- period electrophysiological and clinical findings following carpal tunnel syndrome: is EMG necessary? *Int J Clin Exp Med*. 2015;8:6267–71.
7. Kwon M, Kim DJ, Cho H, Yang S. The smartphone addiction scale: development and validation of a short version for adolescents. *PLoS One*. 2013;8:e83558.
 8. Demirci K, Orhan H, Demirdas A, Akpınar A, Sert H. Validity and reliability of the Turkish version of the Smartphone Addiction Scale in a younger population. *Klinik Psikofarmakoloji Bülteni*. 2014;24:226-34.
 9. Gummesson C, Ward MM, Atroshi I. The shortened disabilities of the arm, shoulder and hand questionnaire (QuickDASH): validity and reliability based on responses within the full-length DASH. *BMC Musculoskelet Disord*. 2006;7:44.
 10. Koldas Dogan S, Ay S, Evcik D, Baser O. Adaptation of Turkish version of the questionnaire Quick Disability of the Arm, Shoulder, and Hand (Quick DASH) in patients with carpal tunnel syndrome. *Clin Rheumatol*. 2011;30:185-91.
 11. Carlsson AM. Assessment of chronic pain. I. Aspects of the reliability and validity of the visual analogue scale. *Pain*. 1983;16:87-101.
 12. Procedure and conditions of electrophysiological testing to determine the degree of seriousness of isolated CTS. *Bull Ministry Health*. 2003;10. Czech.
 13. Willemse I, Waller G, Süß D, Genner S, Huber AL. JAMES–Jugend, Aktivitäten, Medien – Erhebung Schweiz. Zürich, Zürcher Hochschule für Angewandte Wissenschaften, 2012.
 14. Medienpädagogischer Forschungsverbund Südwest. JIM 2013. Jugend, Information, (Multi-) Media. 2013. Basisstudie zum Medienumgang 12- bis 19-Jähriger in Deutschland.
 15. Buller DB, Berwick M, Lantz K, Buller MK, Shane J, Kane I et al. Smart phone mobile application delivering personalized, real-time sun protection advice: a randomized clinical trial. *JAMA Dermatol*. 2015;151:497-504.
 16. Kim YJ, Rhee SY, Byun JK, Park SY, Hong SM, Chin SO, et al. A smartphone application significantly improved diabetes self-care activities with high user satisfaction. *Diabetes Metab J*. 2015;39:207-17.
 17. Demirci K, Akgönül M, Akpınar A. Relationship of smartphone use severity with sleep quality, depression, and anxiety in university students. *J Behav Addict*. 2015;4:85–92.
 18. Maryam A, Muhammad A, Syed HD, Farah A, Afshen I, Syed HD. Frequency of De Quervain's tenosynovitis and its association with SMS texting. *Muscles Ligaments Tendons J*. 2014;4:74-8.
 19. Fernandez-Guerrero IM. whatsappitis. *Lancet*. 2014;383:1040.
 20. İnal EE, Demirci K, Çetintürk A, Akgönül M, Savaş S. Effects of smartphone overuse on hand function, pinchstrength, and the median nerve. *Muscle Nerve*. 2015;52:183-8.
 21. Bouche P. *Encyclopédie médico-chirurgicale*. Paris, Elsevier Masson SAS, 2008.
 22. Corlobé P. L'électromyogramme des syndromes canaux. *Chir Main*. 2004;23:4–14.
 23. Mackinnon SE. Pathophysiology of nerve compression. *Hand Clin*. 2002;18:231-41.
 24. Keir PJ, Bach JM. Flexor muscle incursion into the carpal tunnel: a mechanism for increased carpal tunnel pressure? *Clin Biomech (Bristol, Avon)*. 2000;15:301-5.