

THE IMPACT OF MOBILE TOUCH SCREEN DEVICE USE ON MUSCULOSKELETAL SYSTEM: A LITERATURE REVIEW

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Keywords

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Smartphones
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Abstract

People using mobile touch screen devices (MTSDs) have been exposed to the musculoskeletal disorder because of physical risk factors. As being lightweight; the latest generations of MTSDs are preferred for personal and work purposes as they are comfortable to operate and easy to carry. Furthermore, they have many advantageous facilities compared to conventional devices. This study aims to survey previous researches on the effects of MTSDs use on the musculoskeletal disorder. In this scope; published researches on musculoskeletal disorders, postural problems, and kinematic activities at upper extremities among people who use mobile phones or tablets for daily use are investigated. The articles reviewed were cited based on the research made from Web of Science, Scopus, ProQuest, Elsevier Science Direct, and Google Scholar. The method selected in this study was to review published studies from January 2010 to December 2019 on occurrence of discomfort symptoms in different positions of the body parts and muscular activities in upper extremities among people who use MTSDs.

MOBİL DOKUNMATİK EKLAN CİHAZI KULLANIMININ KAS İSKELET SİSTEMİ RAHATSIZLIKLARINA ETKİSİ: LİTERATÜR ARAŞTIRMASI

Anahtar Kelimeler

Mobil cihazlar
Akıllı telefonlar
Tabletler
Dokunmatik ekran
Kas ağrıları

Öz

Fiziksel risk faktörleri nedeniyle dokunmatik ekran mobil cihaz (DEMC) kullanan kişiler arasında kas-iskelet patolojisi oluşmaktadır. Hafif olmaları nedeniyle; işlem yapmada, taşımada ve birçok yönden daha avantajlı olduklarından son dönem DEMC kişisel ve iş kullanımında tercih edilmektedirler. Bu çalışmanın amacı DEMC kullanımının kas-iskelet sistemi üzerine olan etkisini içeren literatürdeki alışmaları incelemektir. Bu kapsamda; günlük olarak mobil telefon ve tablet kullanan kişilerde meydana gelen üst ekstremitelerdeki kas-iskelet sistemi rahatsızlıkları, postürel sorunlar ve kinematik aktiviteler araştırılmıştır. Bu çalışmadaki atıflar Web of Science, Scopus, ProQuest, Elsevier Science Direct ve Google Scholar veritabanları taranarak kullanılmıştır. Bu çalışmada uygulanan yöntem Ocak 2010 ve Aralık 2019 yılları arasında yayınlardaki DEMC kullanıcılarının vücudun çeşitli bölgelerinde ortaya çıkan rahatsızlık semptomlarını ve kas faaliyetlerini içeren çalışmaların taranmasıyla gerçekleştirilmiştir.

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1. Introduction

The last two decades have witnessed great changes in the mobile technologies, such as smartphones, introducing tablet computers (tablets), especially in using the touch screen facility rather than any previous indirect methods. The use of touch screen was observed to have negative impacts on the musculoskeletal disorder or caused injuries when not used properly (Szucs, Cicuto and Rakow, 2018). The mobile devices are considered to be as the main equipment that is comfortably used for business and personal purposes. For this reason, it does not need to use any intermediary equipment (Genaro Motti, Vigouroux and Gorce, 2014).

The spread of touch screen devices has been widely increasing among adults and children in the last decade (Poushter, 2016; Rideout, Foehr and Roberts, 2010). Using electronic devices, such as computers or tablets, has shown discomforts and postures for children (Shan et al., 2013; Szucs et al., 2018). As a result to its portability, touch screen devices users may use them in different situations like in the public transportation or on a couch, which may be referred to as a possible cause for musculoskeletal disorders than using them while sitting at a desk (Toh, Coenen, Howie and Straker, 2017; Werth and Babski-Reeves, 2014).

Actually, one of the major factors contributed to diverse types of musculoskeletal disorders is the use of computers (Ming and Zaproudina, 2003). For example, the long time spent in using handheld and computers devices, such as spending lengthy sessions in the same postures, can have an impact on different areas of the body, such as fatigue and neck pain (Green, 2008; Sharan, Mohandoss, Ranganathan and Jose, 2014). The recent literature shows that using computers causes sleep disturbances, psychological disturbances, and headaches (Jomoah, 2014; Thomée, Härenstam and Hagberg, 2012).

Many studies in the literature indicate a negative impact on the users' psychological and physiological health as a result of the prevalent use of handheld devices with touch screen (Razvi, Shewale and Khatib, 2018). Due to the constant use of mobile devices, the users develop musculoskeletal disorders (MSD) in their hands, forearms, arms, and necks (Al-Khlaiwi and Meo, 2004; Razvi et al., 2018).

Using mobile devices, which has been increasing in the twenty first century, necessitates having studies to examine the effect of such devices over the users' health (Szucs et al., 2018). Since the impact of these devices is now a worldwide phenomenon that affects in musculoskeletal disorders, there are several studies conducted to reduce the risk and improve

devices for users. Hence, the design of these devices is very vital to prevent risks that might occur. This research, therefore, intends to review the recent literature about musculoskeletal disorders and exposures related to the use of MTSDs. The results of this study may form a guide for the future research about the MTSDs and the research related to them.

2. Methodology

This research focuses on studies about physical impacts of touch screen devices on musculoskeletal disorders. Therefore this reviews included articles published from January 2010 up to December 2019, were searched using keywords and (MSK) musculoskeletal disorders (e.g. discomfort, pain, and ache) and (MTSDs) mobile touch screen devices.

3. Literature Review

In this study, the results of the search focusing on the preferences of users for electronic devices such as mobile phones and touch screen devices for many daily purposes like the educational, communication and social media as well as researches focusing on effects of these devices use on musculoskeletal symptoms/disorders (Binboğa and Korhan, 2014; Gustafsson, Coenen, Campbell and Straker, 2018; Gustafsson, Thomee, Grimby-Ekman and Hagberg, 2017; Woo, White and Lai, 2016). These studies have been highlighted, in the review on physical effects important of these mobile technologies. Therefore, it should not be prolonged usage of these devices at the expense of musculoskeletal disorder.

The fast frequency of fingers movements is an important factor for the development of musculoskeletal symptoms/disorders, since there is activation of co-contraction in neck and upper limb muscles and a need of variety in activation of motor-units (Rissén, Melin, Sandsjö, Dohns and Lundberg, 2000; Sjøgaard, Lundberg and Kadefors, 2000). Repetitive and pushing movements (e.g. typing and during pipetting) are considered to cause risks of musculoskeletal disorders within the thumb and the extrinsic thumb musculature within the lower arm (Moore, 1997).

Many studies in the field are interested in determining and examining the muscle activities and the factors of the physical impact risk resulted from the use of electronic devices (Maslen and Straker, 2009; Zovkić, Vrbanec and Jasminka, 2011). On other hand, the current technological development in the world that to change the designs of this type electronic devices. Where became with smaller size, more easier and carrying to used, as well as there are

many available facilities that makes advantageous them. Thus there are many present studies of mobile touch screen devices (e.g. smartphone and tablets) associated with their use by users for all purposes on musculoskeletal disorders and muscle activity (Binboğa and Korhan, 2014; Gustafsson et al., 2018; Gustafsson et al., 2017; Woo et al., 2016).

The researchers try to find the variation in muscle activity regarding the conventional devices use of individuals and interactions over processes and tools (Breen, Pyper, Rusk and Dockrell, 2007; Ciccarelli, Straker, Mathiassen and Pollock, 2006; Harris, 2010). Nevertheless, the electronic gadgets of new technologies like, smaller size in design (e.g. screens and keyboard buttons) causes to intense movements needed for example to texting, playing game, video watching, etc. These movements have been associated with increased loading in upper extremities and muscle stress on the users. Therefore, there should be of concern of physical impacts of the usage that may have negative effect on musculoskeletal symptoms and exposures.

3.1. Study Characteristics

The involved investigations were from altered countries with varied answer rates from 62.2% to 100% (Table 1). Students were the main participants in these (Chiang and Liu, 2016; Gustafsson et al., 2018; Im, Cho, Park, Jung and Park, 2010; Kietrys, Gerg, Dropkin and Gold, 2015; Kim and Kim, 2015; Namwongsa, Puntumetakul, Neubert and Boucaut, 2018; Szucs et al., 2018; Woo et al., 2016; Xiong and Muraki, 2014; Jin, Kim, Park, Chang and Kim et al, 2019). On other hand, some scholars in other studies also employed working participants (Lee, Hsu, Bair, Toberman and Chien, 2018; So, Cheng and Szeto, 2017; Wilaiwan and Siriwong, 2019). Types of mobile devices used in the designated studies encompassed tablets (Chiang and Liu, 2016; Lee et al., 2018; Razvi et al., 2018; Szucs et al., 2018), handheld electronic game devices (Razvi et al., 2018; Woo et al., 2016; Wilaiwan and Siriwong, 2019) and mobile phones which consisted of cell phones, keypad phones, smartphones and touchscreen phones (D'Anna et al., 2018; Gustafsson et al., 2018; Gustafsson et al., 2017; Im, Cho, Park, Jung and Park, 2010; Kietrys et al., 2015; Kim and Kim, 2015; Korpinen, Paakkonen and Gobba, 2013; Namwongsa et al., 2018; Razvi et al., 2018; So et al., 2017; Szucs et al., 2018; Werth and Babski-Reeves, 2014; Woo et al., 2016; Xie, Szeto and Dai, 2017; Xiong and Muraki, 2014, Wilaiwan and Siriwong, 2019; Jin, Kim, Park, Chang and Kim et al, 2019). Day-to-day duration of the use of the smartphone devices fluctuated between 1 hour to 6 hours among users (D'Anna et

al., 2018; Kim and Kim, 2015; Namwongsa et al., 2018; Razvi et al., 2018; So et al., 2017; Woo et al., 2016; Wilaiwan and Siriwong, 2019). Participants used their handheld devices frequently for the following activities; making phone calls, texting messages, internet browsing and playing games, as informed by the encompassed studies (Chiang and Liu, 2016; D'Anna et al., 2018; Gustafsson et al., 2018; Gustafsson et al., 2017; Kietrys et al., 2015; Kim and Kim, 2015; So et al., 2017; Xiong and Muraki, 2014; Wilaiwan and Siriwong, 2019; Jin, Kim, Park, Chang and Kim et al, 2019).

3.2. Physical Impacts Associated With Use of Electronic Devices on The Musculoskeletal Disorder.

This part is dedicated to review the studies on physical impacts of portable technologies, such as touch screen devices (smartphone, tablet computer and game consoles etc.) over musculoskeletal disorder (Table 2).

In a study conducted at Roma Tre University, fifteen right handed participants aging between (21 up to 25) years were asked to perform with multi-task movements (e.g. video watching, playing, texting and browsing) during sitting and standing to investigate the effect of smartphone use on the changes of neck and trunk posture. The results obtained after analyzing questionnaire data, indicated that 66.6% participants reported neck and/or shoulder pain. Yet, there was no significant differences between the activities on standing and sitting position in the neck angle. Results suggest that there were risk factors may lead to neck pain, musculoskeletal fatigue and disorders, due to the postures changes during smartphone use (D'Anna et al., 2018). Another study conducted by Jin et al, (2019) aimed to find the difference between using smartphones and smartwatch while participants were sitting and standing. The results showed that the smartwatch had a significant, impact on the participants on greater muscle activities, head flexion, and shoulder abduction compared to smartphones (Jin et al., 2019).

A cross-sectional analysis study was conducted by Namwongsa et al. (2018) about the use of smartphones. The study included 779 Thai participants who have been using smartphones for more than 12 months. The results show that there was flexion neck posture resulted from the use of smartphones by 82.74% and the prevalence of musculoskeletal disorders was highest in the neck 32.50% of the participants. The study suggests that the initiatives studies should be made to reduce flexed neck postures for the users as it has become a serious problem in the society. Another study was

conducted by Wilaiwan et al. (2019) in Thailand as well. The study aimed to evaluate the health effects and identify the factors associated with the health effects of tablets and smartphone among older users. The study was a cross-section descriptive, including 490 elderly participants. The results showed that

after a three month period, the participants came across five different health issues. Eye pain showed the highest percentage of 59%, shoulder and neck pain 49%, and wrist and headache around 38% (Wilaiwan and Siriwong, 2019).

Table 1. Physical Impacts Study Characteristics of Included Studies

First author (year)	Study design	Country	Response rate (%)	Age	Sampling frame
D'Anna et al. (2018)	Cross-sectional study	Italian	15/15 (100%)	21-25	Young adults
Namwongsa et al. (2018)	Cross-sectional study	Thailand	643/799 (80.5%)	17-26	Undergraduate students
Gustafsson et al. (2018)	Cross-over design	Australia	19/19 (100%)	21-51	University students
Kim et al. (2015)	Survey	Korean	292/292 (100%)	21.42 ± 1.57	Dental hygiene students
Xiong et al. (2014)	Experiment	Japan	20/20 (100%)	24.5 ± 2.2	University students
Kietrys et al. (2015)	Experiment	USA	20/20 (100%)	18-28	College students
Xie et al. (2017)	Electronic database search	Unclear	Unclear	Unclear	Unclear
Szucs et al. (2018)	Survey& lab	Unclear	21/21 (100%)	21.1 ± 1.5	College students
Lee et al. (2018)	Cross-sectional survey	USA	315/412 (76.5%)	>18	University population
Razvi et al. (2018)	Cross-sectional study	India	402/402 (100%)	18-35	Medical College Hospital
Chiang et al. (2016)	Laboratory & survey	Taiwan	80/80 (100%)	>20	College students
So et al. (2017)	Cross-sectional design	China	285/437 (65.2%)	18-50	local university and nearby physiotherapy clinics
Woo et al. (2016)	Survey	China	503/503 (100%)	18-25	University students

Gustafsson et al. (2017)	Cross-sectional study	Sweden	7125/20000 (35.6%)	20-24	Young adults
Jin et al. (2019)	Experiment	Korea	14/14 (100%)	26.7	University population
Wilaiwan et al. (2019)	Cross-sectional descriptive	Thailand	490/490 (100%)	64.9. ± 5.4	Elderly people
Im et al. (2010)	Experimental design	Korea	10/10 (100%)	26 - 35	Korea University

Kim and Kim (2015) investigated the correlation between smartphone use and musculoskeletal symptoms. Significant pain in neck and shoulder of the body positions were found. Besides, positive correlation with the size of the smartphone's use was mostly found in neck and shoulders while the results found in legs and feet showed negative correlation. Additionally, Xie et al (2017) conducted a systematic review to determine the musculoskeletal disorders caused by mobile handheld use. The method followed in that study was based on the database of the published studies related to the risk factors of musculoskeletal disorders. The obtained results indicate that there are neck complaints reaching up to 67.8%. Moreover, Gustafsson et al (2017) underlined that there is a significant risk factor for hands, neck, and upper back when texting messages. The study has also noticed text messaging has its effects mainly in the short term.

In their study, Gustafsson et al (2018) compared the upper limb muscle activity with the thumb kinematics

for typing with keypad phones and touchscreen. The study had 19 participants of both genders (21 to 51 years) from Curtin, Perth, and Australia Universities. The results state that there are significant differences in the risks due to mobile touch screen devices use that causes musculoskeletal disorders. The findings also suggest that while using smartphones, there is a high possibility for developing musculoskeletal disorders with the different key action tools. The study has revealed that the participants with shorter hands have differences in thumb flexion, while those with longer hands have differences in muscle activity. Im et al (2010) conducted a study about the controllability of Touch-screen phones based on various grip postures. The study included 10 Korean males between 26 and 35. The results show that the participants preferred using the index finger to the thumb in using the touch screen devices. The thumb was not preferred due to restrictions on motion and difficulties in reaching the needed objects (Im, Cho, Park, Jung and Park, 2010).

Table 2. Summary of Researches About the Musculoskeletal Disorders As Results of Using Electronic Devices.

Author	Type of MTSD	Quantitative or experimentation measurement	Study design	Results
Szucs et al. (2018)	Tablet, laptop, Mobile phone	-Screening protocol to determine eligibility -Posture Screen Mobile® Application	- N= 21 (3 males and 18 female). -Right hand dominant.	Neck flexion is mainly caused by the use of tablets

D'Anna et al. (2018)	Smartphone	Questionnaire	-N= 15 -Multi-task (sitting and standing)	66.6% subjects reported neck and/or shoulder pain
Lee et al. (2018)	Tablet computer	Questionnaire	N= 412 (135 males and 275 female)	67.9% was the highest prevalence of musculoskeletal symptoms
Razvi et al. (2018)	Electronic devices (Pc gaming devices and smartphone)	Cross-Sectional	N= 402 ((209 males and 193 female)	Two-thirds majority Significant neck pain and fatigue
Gustafsson et al. (2018)	Smartphone	-laboratory study -3D motion analysis system -EMG electromyography	N= 19 (12 males and 7 female)	In muscle activity, the group of shorter hands have differences in thumb flexion, as well as the longer hands group
Chiang et al. (2016)	Tablet computer	-Questionnaire -3D motion analysis system	N= 80 (26 males and 54 female)	Significantly musculoskeletal discomfort and neck flexion angle when games playing
So et al. (2017)	Computers and mobile phones	Cross-Sectional	N= 285 (140 males and 145 female)	There are a significantly associations with neck pain, for both laptop and keypad phone time.
Xie et al. (2017)	Mobile handheld devices	Electronic database search	PubMed, Medline (1946 via OvidSP), Web of Science, CINAHL (1982) and Embase (1980) were searched	High percentage prevalence musculoskeletal symptoms were in the neck complaints between who mobile devices users, also neck flexion.
Xiong et al. (2014)	Smartphone touch screen	-Experiment -EMG electromyography	-N= 20 (10 males and 10 female) -Right hand dominant	Significant thumb fatigue when tapping.
Namwongsa et al. (2018)	Smartphones	Cross-Sectional	N= 643 (184 males and 459 female)	There is a significant pain at neck.
Woo et al. (2016)	Computers, mobile phones and game consoles	Questionnaire	N= 503 (297 males and 206 female)	49.9% upper limb musculoskeletal symptoms

Kietrys et al. (2015)	Mobile devices (physical keypad phone, touch screen phone, and touch screen notepad)	-A video camera -EMG electrodes	-N= 20 (4 males and 16 female) -Right hand dominant.	Size of touch screen devices have an effect of greater finger flexor, wrist extensor, and muscle activity.
Gustafsson et al. (2017)	Mobile phone	-A longitudinal study -Questionnaire	N= 7092 (2759 males and 4333 female)	The long term effects showed extensive disorder on the neck.
Kim et al. (2015)	Smartphone	Questionnaire	N= 292	The most severe pain was seen at the shoulders and neck
Jin et al. (2019)	Smartphone Smartwatch	EMG electrodes	N= 14 (males)	Significant influence of the smart device type on the trunk postures.
Wilaiwan et al. (2019)	Smartphones Tablets	Questionnaire	N= 490 (267 males and 223 females)	Increase in physical health effects such as eye symptoms and musculoskeletal symptoms.
Im et al. (2010)	Touchscreen devices	Laboratory	N=10 (males)	Users preferred an index finger to a thumb usage.

Xiong and Muraki (2014) conducted a study about the daily use of smartphones for 20 right-handed participants at Kyushu University. The study examined the thumb motions on touchscreen devices. The results showed that the thumb has developed rapid fatigue for kinematics gestures. For example, when tapping on smaller buttons compared with bigger, the thumbs moved more slowly in flexion-extension compared to adduction-abduction orientation. Additionally, the muscle effort among thumb muscles on a touchscreen smartphone depends on the task to be done on the touchscreen.

There are many studies to investigate the physical impacts of tablet computers in relation to usage. Lee et al (2018) conducted a study to examine the significant risk factors of musculoskeletal symptoms during a three month period. The data was collected from 412 participants (135 men and 275 female) at a school population via online questionnaire. The study concentrated on the use of tablet computer. The results showed that 67.9% suffered from the highest prevalence of musculoskeletal symptoms due to tablet use. The participants with musculoskeletal symptoms showed a significant number in the upper limb body (84.6% neck and 65.4% upper back/shoulder). The study also showed that females had double effect of musculoskeletal symptoms than that of males.

Moreover, Chiang and Liu (2016) conducted surveyed the students and analyzed the results using a 3D Motion analysis system to determine the effects of tablet usage. The results have indicated the significant musculoskeletal discomfort (neck, shoulders, and back) as well as neck flexion angle during playing games. Szucs et al (2018) conducted a study about the effects of using different handheld devices. The results show that using tablet has negative effects that are greater than the ones in any other handheld device. The researcher found that 85.6% of the participants used touchscreen devices for more than 3 hours a day, which has caused significant neck pain and fatigue.

Generally, there are studies associated with the using of mobile devices as such touchscreen phones, time spent tasks frequently performed. Razvi, Shewale, and Khatib (2018) made a study which included 402 patients of a medical college and hospital, aging between 18 and 35. The study examined the daily use of electronic mobile devices associated with disorders and symptoms. To detect the risk factors, Chi-square analysis was done in this study. The researcher found that 85.6% of the participants used touchscreen devices for more than 3 hours a day, which has caused significant neck pain and fatigue (Razvi et al., 2018). In addition, the result of So et al (2017) indicated that the rate who use touch screen phones was 89.8%, which was much higher than any other devices used. The

results also show that the most common areas of musculoskeletal discomfort were in the neck and shoulder (So et al., 2017).

A study was conducted by Woo et al (2016) about the use of computers, mobile phones, and game consoles for university students in Hong Kong. The study lasted for 12 months and included 503 participants. The results showed that around half of the participants has reported upper limb musculoskeletal symptoms (neck and shoulder) resulted from the use of electronic devices.

The slate computer resulted non-neutral wrist, elbow, and neck postures when working on the sofa more than any other position. Performance on the slate computer was four times less than that of the other computers though lower muscle activity levels were also found (Werth and Babski-Reeves, 2014).

4. Conclusion

The overall purpose of this review was to investigate the impact of electronic touchscreen devices and possible problems related to educational, communication, and entertainment uses. Additionally, the literature review aimed to explore a musculoskeletal effects as a result the use of diverse types of electronic devices.

We have inspected the literature and reviewed some published studies related to activities of musculoskeletal, posture and the possibility of discomfort in the musculoskeletal among users for mobile touch screen devices

This review explores the physical impact of touch technologies and shows that greater painful areas in the neck, shoulders, and neck flexion posture, as well as more activities like (texting, frequency of phone calls and gaming), are associated with musculoskeletal disorders muscle activity around the neck., also the highest proportion of use the technologies devices among users are the touchscreen devices.

There is no specific prevalent risk assessment method among users; studies relevant to the musculoskeletal disorder of technologies devices are really inadequate. Therefore, it is useful to conduct further experimental studies related to the use of devices to address the potential complaints and reduce effects of using musculoskeletal disorders.

Conflict of Interest

No conflict of interest was declared by the authors.

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