ORIGINAL ARTICLE

PRELIMINARY STUDY ON EFFECT OF HANDEDNESS IN UNILATERAL AND BILATERAL TYPING TASK TOWARDS MUSCLE ACTIVITY OF UPPER ARM AND SHOULDER MUSCLES.

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ABSTRACT

The smartphone has been used widely in daily life for communication, business, security and writing. Nevertheless, studies of smartphone product design influences on handedness are quite limited. The objective of this study is to investigate the handedness effect of unilateral (right hand) and bilateral (both hands) typing task using a smartphone on hand muscle activities. Six participants ranging from 23 – 26 years old with minimum of 2 years of experience using the smartphone performed typing task. The surface electromyogram (sEMG) signal of External Carpi Radialis (ECR), Biceps Brachii (BB) And Trapezius (UT) from both right and left hands were recorded during the typing task of 3 minutes with 10 seconds rest interval. The percentage of Maximum Voluntary Contraction (%MVC) of unilateral typing method is higher as compared to both hands typing method. The comparison of left and right hand when both hands typing showed that the left-handed (LH) participants having high muscle activities on the left hand while for right-handed (RH) participant, all muscle activities were higher on the hand. In conclusion, the study confirms that the usage of a smartphone using one hand is prone to more fatigue compare using both hands. Besides, non-dominant hand user also showed higher muscle activation of the same muscle with dominant hand users. This means faster fatigue condition for the non-dominant users in the one-handed typing method.

Keywords: *Electromyography, Hand dominance, Smartphone, Maximum Voluntary Contraction*

INTRODUCTION

Smartphone has become a trending device in the world because several factor such more compact and capability than a computer, have good portability and designed to optimize work. It is reported by Statistica (2019) that in 2019, the number of smartphone users worldwide was 3.5 billion while the 2018 handphone user survey by Malaysian Communication and Multimedia Commission (MCMC,2019) showed 78% of 2401 respondents smartphone and majority of the users were in age range of 20-34 years old. With the increase of smartphone usage, there are concerns on potential risks to musculoskeletal health and discomfort at the upper limb. Berolo, Wells and Amick (2011) reported significant findings were seen between time spent gaming on a typical day and any pain or discomfort reported in the middle of the right and left thumbs while Namwongsa, Puntumetakul, Neubert, Chaiklieng and Boucaut (2018) found that upper limb posture while using mobile phones had effects on neck musculoskeletal disorders.

Among popular use of smartphone is texting using application for social and work-related purposes. From the previous study by Kietrys, Gerg, Dropkin and Gold (2015), performing a typing task using the small keypad on smartphone risks could lead to disorders. According to some studies such as Namwongsa et al. (2018) and Gustafsson, Thomée, Grimby-Ekman and Hagberg (2017), thumb and forearms muscle disorder can occur due to typing task using on a smartphone because prolonged holding smartphone and repetitive movement even when low stress was exerted on the smartphone. In addition, Kim et al. (2016) reported that the typing task could generate the repetitive strain injury (RSI) that occurs when the nerves, muscles or ligament damaged in repetitive use while Kim and Koo (2016) suggested that prolonged typing smartphone could cause musculoskeletal problem at neck and shoulder.

Handedness is a form of human's attribute that is defined by unequal distribution of fine motor skills between the right and left hand. Most products including smartphones are designed for right-handed dominant users due to 90% world population are right-handed. Hence left-handed people would have to adapt to the products when using them. Mouloua, Mouloua, McConnell and Hancock (2018) studied on motor performance using a mouse in mouse-pointing task and Rasyad and Muslim (2019) found that the writing using writing armchair with desktop fixed for righthanded persons had could not write well due to discomfort they felt.

Nonetheless, limited studies are reported to identify hand performance of non-dominant hands during texting using a smartphone, especially in prolonged usage. Thus, it is

important to understand the effect of prolonged use of smartphones towards human physiology. Although many studies such as Trudeau, Udtamadilok, Karlson and Dennerlein (2012), Kietrys et al. (2015) and Gustaffson, Johnson, Lindegård and Hagberg (2011) had reported on arms muscles, mainly the researches focus on fingers related muscle but not at the upper arm and shoulder area. Hence, the objective of this study is to investigate the muscles response of forearm (ECR), upper arm (BB) and shoulder muscle (UT) during unilateral and bilateral smartphone typing task.

METHODS

Participant

Five male participants with the age of (24 ± 1.55 years old) and heights of (1.65 ± 0.24 m) which consist of two left-handed user and three right-handed users were recruited for this study. They were pre-screened by taking the Edinburgh Handedness Inventory (Oldfield, 1971) to determine handedness. In addition, the participants must have at least 2 years of experience using a smartphone and did not have any neuromuscular disorder, injuries or a broken bone at forearm and shoulder (Roman-Liu and Tokarski, 2002).

Procedure

The information of age, height and physical measurement of weight of participant is measured and recorded before the experiment starts. Written consent was obtained before the experiment from all the participants. Next, sEMG transmitters were attached to the skin of muscle UT, ECR and Biceps BB. Prior to the experiment, the maximum strength of measured muscles was measured by determining the maximum voluntary contraction (100% MVC). For BB muscles, participants were seated with supinated hand 90° elbow angle and below the heavy table as Nasir, Hayashi, Loh and Muraki (2017) did. They were then lifted the table at maximum effort. With forearm in relaxed but in fisted position on the table, the participants were required to flex wrist as hard as they can to determine ECR maximum effort while for UT, they had to resist downward force applied by the experimenter (Dahlqvist, Nordander, Granqvist, Forsman and Hansson, 2018). These procedures were then repeated for another two times with a rest interval of one minute.

Consequently, the participants were then performed the typing task at a fixed position by sitting on the chair while both hand on the table as in Fig. 1. The adjustable chair was used to fit different height participants with a height of hands on the table. The participants were required to type a paragraph of 32 sentences pangram word in English words by single right hand by using a six inches display smartphone with the dimension of 158 mm height x 76.7 mm width x 7.8 mm in thickness and weight of 155 gram. The duration of a participant performing the typing task about three minutes and with a minimum rest time of about 60 seconds after each trial. This task was repeated for three times. The trials were then repeated by using both hands to type. For this experiment, the number of text repetition to accommodate the three minutes of task time, the typing error and speed of typing were not considered.

Measurements

Surface EMG (sEMG) of UT, BB and ECR was recorded in real-time using the multichannel telemetry system (Myon 320, Schwarzenberg, Switzerland) at a sampling frequency of 1 KHz with band-pass filter 80-150Hz and using surface electrodes (AMBU, Cambridgeshire, UK).

Fig. 1. Typing task position

Six sEMG transmitters were firmly attached to measure BB, UT and ECR on the participants' right and left arm by using disposable adhesive tapes. Before the transmitter attachments, the participant's skin was cleaned with alcohol. The participants practiced the isometric contraction for all muscles involved before the actual experiment started, and palpation was done to identify the locations of the sensors. According to the palpation and the Surface ElectroMyography for the Non-Invasive Assessment of Muscles (SENIAM) guideline, sensors were located at the middle of the muscle belly (Trudeau et al., 2012). The Root Mean Square (RMS) data obtained during maximum effort would be and presented as 100% MVC. The RMS data for each muscle involved the typing task were normalized to obtain %MVC of task.

Data analysis

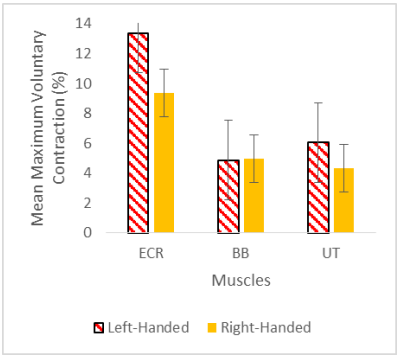
The IBM SPSS (version 25.0 software, USA) was used for statistical analysis. All data are presented as RMS ± SD (Standard Deviation). Repeated-measure analysis of variance was

conducted to evaluate the influences conducted among the single/both hands typing and hand dominance (LH/RH participants). All statistical significance was accepted at $p < 0.05$.

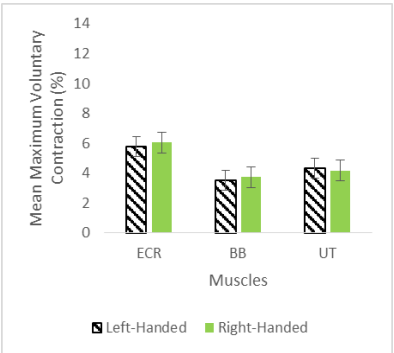
RESULTS

Muscles activities One-Handed and Both-Handed typing method

Fig 2a showed the %MVC of BB, ECR and UT for typing task using the right hand (single hand) while Fig 2b showed the %MVC when typing using both hands (double hand). LH participants were observed to have higher muscle activation of ECR and UT than the RH participants in single- hand typing task, while in bilateral typing task the RH participants exhibit slightly higher muscle activities of ECR and BB.



(a)



(b)

Fig. 2. %MVC between LH and RH of (a) unilateral and (b) bilateral typing task for right hand ECR, BB and UT.

Muscles activities of left hand (LH) and right hand (RH) of both hands typing method.

The comparison of muscles activities between the LH and RH participants when typing both hands is shown in Fig. 3 and Fig. 2b. Similar muscle activity pattern of LH and RH participants was observed in ECR. In addition, significant effect was found in LH participants in ECR. LH participants were also found to activate more UT muscle when using both hands to type as compared to RH participants, while contrast result on BB was observed.

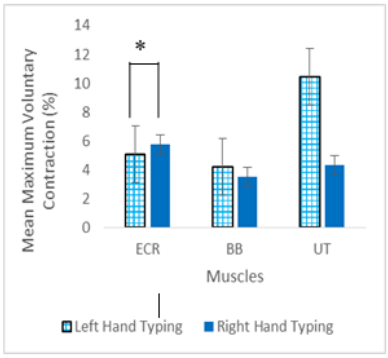


Fig.3. Muscle activity (%MVC) comparison between left hand (LH) and right hand (RH) of left-handed participants for bilateral hand typing.

DISCUSSIONS

For unilateral typing method, the left-handed [LH] participants' ECR and UT muscles showed that more muscle activities were produced during typing one hand because of the participants. It could be happened due to LH participants required more effort to complete the typing task. However, the muscle BB shows that muscle activity is reduced slightly different compare the reading of muscle activity of right-handed. This slight differences in muscle activity may be due to uncontrolled posture during performing the typing task, which is in contrast to finding by Trudeau, Udtamadilok, Karlson and Dennerlein (2012). Nevertheless, the UT %MVC result in this study is concurrent with Trudeau et al. (2012). However, the muscle activity of UT and ECR in the study by Kim et al. (2016) on the comparison one-handed typing at the sitting position were much lower than %MVC in this study. The differences may occur because of the diverse sitting position. Furthermore, the author performed the typing task by the hands was on the rib while in this study, the hands are on the table.

The result from bilateral typing method (%MVC reading of right hand) in Fig. 3 and Fig. 2b showed that the muscles activities of BB for the

right-handed participant is slightly higher as compared to left-handed participants. However, the %MVC is relatively small (less than 7%) which showed that the participants performed steady contractions during bilateral typing. Due to this matter, no significant effect and interaction were found in right-handed participants. When compared between left-handed bilateral typing result (Fig. 3), it can be seen that %MVC of LH typing is higher than right-handed. This is expected as the neural adjustment to perform the task during muscle contraction of the right-hand task was compensated by the left limb as reported by Gordon, Rudroff, Enoka and Enoka (2012).

For ECR, significant effect of bilateral typing towards hand preference were found in lefthanded participants. Though both hands were used for bilateral typing, due to QWERTY keyboard arrangement right hand still was used to type most of the alphabets. Hence the %MVC shown is slightly higher. No significant affect and interaction were found in right-handed participants as the %MVC for both hands should be lower than the left-handed. Meanwhile, the large difference of UT muscle of left side and right side of body could be happened due to the posture of participants' when doing the task. In this preliminary study, the participants posture is not constrained to a fixed posture.

As a conclusion, the unilateral typing method had higher %MVC dan bilateral typing on smartphone. In addition, handedness does not have a significant effect on typing methods. Nonetheless, more participants and female participants should be included for further investigation.

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COMPETING INTERESTS

There is no conflict of interest.

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