

# The Relationship between Usage of Digital Devices and Musculoskeletal Symptoms: A Cross-Sectional Study among University Students in Sarawak

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**Abstract**—Digital devices such as mobile phone, personal computer and laptop are playing a major role in students' life, but if overused they can bring certain impacts on the musculoskeletal system. Objective: To determine the relationship between usage of digital devices and musculoskeletal symptoms among the university students. Methods: A self-administered questionnaire consist of digital devices use items and the Cornell Musculoskeletal Discomfort Question (CMDQ) were administered among 311 university students. Correlation analysis was done by using the SPSS software. Results: The mean age of study respondents was 21.6 years old (SD=1.0). A majority of respondents use mobile phone (94.9%) on a prolonged sitting position ranging from 5.0 to 7.5 hours per day. About 32% to 60% of respondents experienced musculoskeletal symptoms in at least one body part, with higher prevalence on the neck, shoulder, lower back, and upper back. Females are more prone to experience musculoskeletal symptoms. Time spent on digital devices, eye-to-screen distance, body posture, and age of first use were significantly correlated with musculoskeletal symptoms. Conclusions: University students are at a higher risk to experience musculoskeletal symptoms related to the usage of a handheld digital device. If these musculoskeletal symptoms are not prevented, it may further cause dysfunction and disability at young age. To mitigate these problems, some form of targeted health promotion initiative needs to be implemented in the university.

**Keywords**—Digital Devices, Musculoskeletal Symptoms, University Students

## 1 Introduction

In 2019, there were around 4.7 billion mobile phone users worldwide [1]. Smartphones in particular is becoming a necessity among the public, offering wider accessibility to information [2]. In Malaysia, 20 out of 31 million of its population were smartphone users and about 93% of these users are under the age of 25 [3]. Smartphone remains popular among young adults to replace bulky personal computer (PC) or handheld computers (laptop) for sending and receiving emails, chatting, opening and editing documents, surfing, online shopping, and gaming [4]. For students, smartphones

and their applications are among the most widely used technology tools in their daily lives [5]. Smartphone is a popular “learn anywhere” resource [2], which makes it essential for learning activities. With the smartphone, students can share notes between classmates, record lectures, and take pictures of assignments [6]. Other common devices used to access the internet are notebook and followed by PC and game consoles [7].

Though digital devices may have many advantages to the daily life, overuse of digital devices can affect the physical, social and mental health of an individual. For this study we focused on musculoskeletal disorder aspects. For example, long period of time looking into smartphone cause pressure on spine which is in a long term it becomes pain in neck [8]. Pain at the right hand and right shoulder were commonly reported due to excessive total time spent using a digital device [9]. Extensive evidence also linked the use of these devices with physical inactivity, obesity and more depositions of subcutaneous fat [10]. Excessive usage can also lead to antisocial and being mentally affected [11]. Studies of digital devices usage among university students have been conducted in many regions, but studies correlating to musculoskeletal symptoms have not been well explored. This research was conducted to determine the relationship between usage of digital device and musculoskeletal symptoms among university students.

## **2 Research Methods**

This cross-sectional study was conducted among university students from the Universiti Malaysia Sarawak, Sarawak, Malaysia, from December 2017 to April 2018. The study population was among undergraduate students comprising of first-, second- and third-year students. The study excluded those who had minor sport injury for the past 14 days before answering the questionnaire and those who received treatment from any clinic, hospital, traditional practitioner or self-treatment for musculoskeletal symptoms.

Based on the sample size table provided by Krejcie and Morgan [12]), a minimum sample size of 345 was required for this study. Considering the non-response rate at 20%, the sample size was inflated to 431. A total of 363 respondents participated in this study. Nevertheless, 52 cases were excluded due to missing data mainly on digital device use and musculoskeletal symptoms. Thus, only 311 data were available for statistical analysis. A stratified random sampling was used to choose respondents from nine faculties based on their year of study.

A questionnaire to measure usage of digital devices was adopted from Shan, Deng [13]. Digital devices were grouped into three types, which are mobile phone, personal computer and tablet computer or laptop or notebook. The measurement includes the starting age of using the digital devices, time spent on digital devices (hour per day), postures, methods of handling, screen size of digital devices, and eye-to-screen distance.

The validated Bahasa Melayu version of Cornell Musculoskeletal Discomfort Questions (CMDQ) was used to identify musculoskeletal symptoms if they ever experienced it while using or after using the digital devices [14]. The respondents rated the pain and discomfort they had involving the six parts that we measure in this study which are neck, hand, fingers, lower back, upper back and shoulder. A briefing was given to

participants on the basic information about the study. The following formula was used to estimate the total discomfort score with the scoring procedures available in Table 1.

$$\text{Total Discomfort Score} = \text{Frequency score} \times \text{Discomfort score} \times \text{Interference score}$$

**Table 1.** Musculoskeletal symptoms scoring guidelines

Frequency score	Discomfort score	Interference score
Never = 0	Slightly = 1	Not at all = 1
1 to 2 times = 1.5	Moderately = 2	Slightly = 2
3 to 4 times = 3.5	Very = 3	Substantially = 3
Once every week = 5		
Several times every day = 10		

The frequency, percentage, mean, and standard deviation were used to estimate the prevalence of digital devices use and occurrence of musculoskeletal symptoms among university students. The difference of digital devices uses and musculoskeletal symptoms between female and male students was assessed by independent t-test. Bivariate Pearson’s correlation coefficient was used to investigate the relationship between usage of digital devices and musculoskeletal symptoms.

A pilot study was conducted on 30 university students to figure out respondents’ understanding towards the questionnaire. The Cronbach’s alpha for CMDQ items was 0.84 for “pain and discomfort experience”, 0.87 on “how uncomfortable” and 0.91 for “interfere with ability to use digital devices”. The alphas indicate a good reliability for the evaluation of musculoskeletal discomfort among the study population. Pictures were used to show the location of musculoskeletal discomfort on six body parts, semi-reclining position, phone sizes, and mobile phone hand’s positions were provided for better understanding. The questionnaire was prepared in Malay and English language. On average, the survey takes about 15 minutes to complete.

Ethical approval for this study was obtained from the Medical Research Ethics Committee, Universiti Malaysia Sarawak. Permission from nine faculty authorities was also obtained prior to the conduct of the study. Participant information sheet was given to the respondents and consent was obtained from them.

### 3 Results

The average age of the 311 respondents was 21.6 years old (SD= 1.0). Among 311 respondents, 69.8% of them were female with the remaining 30.2% were male students. The number of first year students was 55 (17.7%), followed 176 (56.6%) second year students, and 80 (25.7%) for the third-year students. The ethnicity of respondents was; Malay (146, 46.9%), Chinese and other ethnics (105, 33.8%) and Natives (93, 19.3%).

### 3.1 Types, Frequency and Mean Age of First use of Digital Devices

Fig. 1 shows all respondents used at least one type of digital device, with mobile phone (smartphone) found to be the most popular device (95%), followed by tablet computer, laptop or notebook (70%), and personal computer (32%). The mean age of first mobile phone usage was 13 years old (SD=3.0 years old). Similarly, the starting age for respondent using a personal computer was also 13 years old (SD=4.0 years old), while for tablet and laptop was 15 years old (SD=3.0 years old).

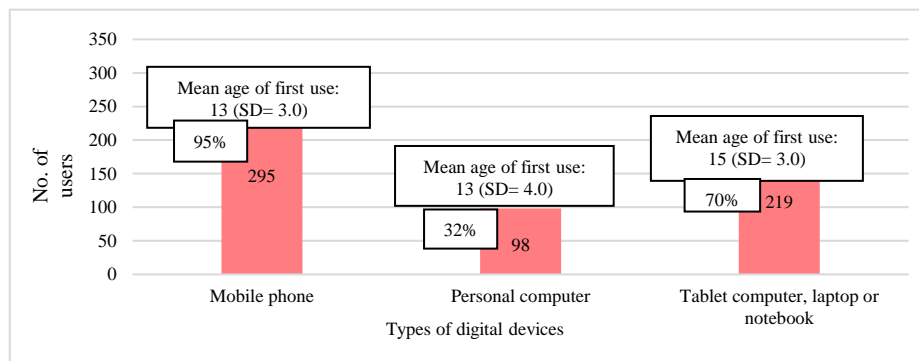


Fig. 1. Types, frequency and mean age of first use of digital devices use

\*Multiple response is allowed

### 3.2 Posture and Time Spent on Digital Devices

Table 2 shows time spent on mobile phone use in a sitting position was 5.0 hours per day (IQR= 5.0). In lying position, the respondents spent 3.0 (IQR= 4.0) hours per day. In semi-reclining and standing position, the median hours per day was 1.0 (IQR= 4.0) and 1.0 (IQR= 2.0) respectively. As for the time spent on tablet, laptop or notebook in a sitting position, the median hour per day was 6.0 (IQR= 5.0). In lying position, the median hour was 1.0 (IQR= 3.0) and no respondents used tablet or notebook on semi-reclining and standing positions. As for the personal computer, there was only sitting position reported as personal computer was fixed in one place. The median hours spent per day was 7.5 (IQR= 5.0).

Table 2. Posture and usage time of digital devices

	Mobile Phone	Tablet, Laptop or Notebook	Personal Computer
	<i>Median (IQR) / (In hours per day)</i>		
Sitting	5.0 (IQR= 5.0)	6.0 (IQR= 5.0)	7.5 (IQR= 5.0)
Lying	3.0 (IQR= 4.0)	1.0 (IQR=3.0)	0.0
Semi-reclining	1.0 (IQR= 4.0)	0.0	0.0
Standing	1.0 (IQR= 2.0)	0.0	0.0

### 3.3 Pattern of Digital Devices use by Screen Size, Hand Position and Eye-to-Screen Distance

The table below shows the usage patterns of mobile phone, personal computer and tablet/laptop/notebook, which were evaluated based on the screen size, hand position, eye-to-screen distance, and sitting with limited movement for 1.5 hours. Among 295 mobile phone users, about 90% of them used the medium and big sized screen. About 65% users preferred single hand to hold mainly using a thumb to operate their mobile phone. As for eye-to-screen distance, 221 (74.9%) respondents use their mobile phone at an unhealthy distance (< 20 cm) (See Table 3).

**Table 3.** Digital devices usage pattern by screen size, hand position and eye-to-screen distance

	Mobile Phone (N=295)	Personal Computer (N=98)	Tablet, Laptop, Note- book (N=219)
<i>(Frequency, %)</i>			
<i>Screen size (inches)</i>			
Small (3.5” – 4.4”)	29 (10)		
Medium (4.5” – 5.4”)	155 (52)	NA*	NA*
Big (5.5” – 6.5”)	111 (38)		
<i>Preferred hand position</i>			
Single hand to hold, mainly using a thumb to operate	192 (65)		
One hand to hold, another hand to operate	28 (10)	NA*	NA*
Both hands to hold, using both thumbs to operate.	75 (25)		
<i>Eye-to-Screen Distance (cm)</i>			
Unhealthy (< 20 cm)	221 (75)	78 (80)	130 (59)
Healthy (> 20 cm)	74 (25)	20 (20)	89 (41)
<i>Sitting with Limited Movement for 1.5 hours</i>			
Limited movement for 1.5 hours	NA	58 (59)	NA

\* NA = Not applicable

Among the 98 personal computer users, eye-to-screen and usage by little movement for 1.5 hours were assessed. As for eye-to-screen distance, 80% of users were using their personal computer at an unhealthy distance (< 30 cm). There are 59% of users who use personal computer in the sitting position with little movement for 1.5 hours. For tablet computer, laptop and notebook, a total of 130 (59%) users use the devices at an unhealthy eye-to-screen distance.

### 3.4 Occurrence of Musculoskeletal Symptoms

Figure 2 shows the occurrence of musculoskeletal symptoms among 311 respondents. The highest occurrence of musculoskeletal symptoms was on the neck (60%), followed by the shoulder (56%), lower back (47%) and upper back (46%). Hands and

fingers came in last, recording 38% and 32% respectively. Comparatively, female students experienced more musculoskeletal symptoms on the neck ( $p=0.004$ ), shoulder ( $p<0.001$ ), hands ( $p<0.001$ ), fingers ( $p=0.001$ ) and lower back ( $p=0.003$ ) compared to male students.

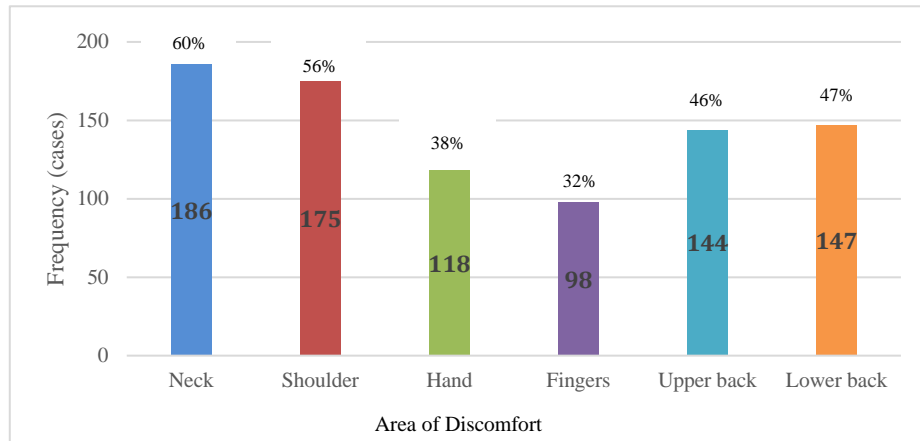


Fig. 2. Occurrence of musculoskeletal symptoms and discomfort

### 3.5 Correlation between usage of digital devices and musculoskeletal symptoms

Table 4 shows correlations between time spent while using digital devices and regional musculoskeletal discomfort scores. For time spent on mobile phone, it was positively correlated with shoulder ( $r=0.12$ ,  $p=0.02$ ); hands ( $r=0.16$ ,  $p<0.001$ ); upper back ( $r=0.12$ ,  $p<0.001$ ); and lower back ( $r=0.16$ ,  $p<0.001$ ). For time spent on tablet, the positive correlation is at hands ( $r=0.14$ ,  $p=0.03$ ) and at upper back ( $r=0.21$ ,  $p<0.001$ ). These positive correlation results show that the longer time spent on mobile phone and tablet, the higher the discomfort scores experienced on the respective body parts. However, the results show no significant correlation between time spent on personal computer with musculoskeletal symptoms.

The starting age of using devices have a significant negative correlation with lower back pain,  $r=-0.13$ ,  $p=0.02$ . This indicates that the earlier the starting age of using digital devices, the more discomfort will be experienced at lower back. The eye to screen distance for mobile phone use was correlated with upper back discomfort ( $r=0.13$ ,  $p=0.02$ ) and lower back ( $r=0.12$ ,  $p=0.04$ ). The eye to screen distance while using tablet was correlated with neck pain ( $r=0.15$ ,  $p=0.02$ ), while eye to screen distance while using personal computer was correlated with shoulder discomfort ( $r=0.21$ ,  $p=0.03$ ). All these positive relationships indicate that the more distance the eye to screen, the more effect on the upper back, lower back, neck and shoulder discomfort.

In terms of body posture, hours spent (per day) using digital devices in sitting position was correlated with neck discomfort ( $r=0.34$ ,  $p<0.001$ ) and upper back discomfort ( $r=0.37$ ,  $p<0.001$ ). While semi-reclining position was correlated with lower back discomfort,  $r=0.49$ ,  $p<0.001$ . These positive relationships suggest that the more time spent

in sitting and semi-reclining position, the more neck, upper back and lower back discomfort.

**Table 4.** Correlation between usage of digital devices and musculoskeletal symptoms scores at neck, shoulder, hands, fingers, upper back and lower back (N=311)

	Musculoskeletal Discomfort Score at Different Body Parts					
	Neck	Shoulder	Hand	Fingers	Upper back	Lower back
<i>Time spent using devices (hours/per day)</i>						
Mobile phone	0.11	<b>0.12*</b>	<b>0.16**</b>	0.10	<b>0.23**</b>	<b>0.16**</b>
Tablet	0.08	0.04	<b>0.14*</b>	0.07	<b>0.21**</b>	0.08
Personal computer	0.16	0.04	0.14	0.02	0.06	0.09
<i>Age started using devices (years)</i>						
Mobile phone	-0.06	-0.002	-0.01	-0.06	-0.09	<b>-0.13*</b>
Tablet	-0.04	-0.03	-0.08	-0.05	-0.04	-0.10
Personal computer	-0.02	-0.06	-0.06	-0.01	-0.03	-0.01
<i>Eye-to-screen distance (cm)</i>						
Mobile phone	0.07	0.09	0.04	0.01	<b>0.13*</b>	<b>0.12*</b>
Tablet	<b>0.15*</b>	0.06	0.08	0.04	0.09	0.08
Personal computer	0.15	<b>0.21*</b>	0.03	0.04	0.06	0.04
<i>Posture (hours/day)</i>						
Sitting	<b>0.34**</b>	0.02	0.07	0.10	<b>0.37**</b>	0.22
Semi-reclining	0.05	0.31	0.07	0.17	0.22	<b>0.49*</b>

\* Significant at the 0.05 level (2-tailed)

\*\* Significant at the 0.01 level (2-tailed)

## 4 Discussion

### 4.1 Prevalence of Musculoskeletal Symptoms

This study showed that certain patterns of digital device usage are correlated to musculoskeletal symptoms, which could lead to disorders and disability. Worldwide, low back pain alone is the single leading cause of disability [15]. As university students spent more time using digital devices, they are at a higher risk in developing musculoskeletal disorders at young age. In this study, about 32% to 60% of university students experience musculoskeletal symptoms at least at one body parts. The symptoms are highest at the neck, followed by the shoulder, lower back, upper back, hands and fingers. This finding is in congruent to Toh, Coenen [16] findings, where neck and shoulder symptoms had the highest prevalence rates reported among mobile touch screen devices users, ranging from 26.3% to 60%.

Musculoskeletal symptoms seem to be significantly higher in female as widely reported in previous findings [17, 18]. Female commonly experience lower back pain, neck and shoulder pain as compared to male. Being female increases the risk by almost a two-fold for musculoskeletal symptoms specific on lower back pain [19]. Few reasons

that contributed to this result is related to some hormonal changes in female during menstruation [20] and also female tends to have lower pain threshold than male, which could influence their answer on the questionnaire.

#### **4.2 Musculoskeletal Symptoms Associated with Hand Position of Digital Devices use**

In our present study, mobile phone found to be the most popular device used by the university students with an average time spent of 10 hours a day. Similar time spent of average 10 hours a day was reported among computer users in a study conducted in University Utara Malaysia [21]. Sharan, Mohandoss [22] stated that smart phones and other digital devices that promoted the use of only one finger (or predominant thumb) while texting, were linked with a higher occurrence of musculoskeletal symptoms.

The present study found about 66% of respondents preferred to hold the phone single-handedly, mainly using a thumb. This is consistent with the results of Rau, Zhang [23], where 75% of all interaction with the mobile phone is carried out with a single thumb. With the continuous repetition of the movement of the hands and fingers, there will be an increase in stress and discomfort. Subramani Parasuraman, Yee [24] detailed out that one-handed use specifically increased pressure-induced pain due to the stress and tension given to this area while using gadgets especially handheld devices. The repetitive upper extremity movements required by handheld devices use, make continuous muscle contraction on the neck and shoulders, which may result in musculoskeletal symptoms. This is because of microscopic damage to the muscles, nerves, and blood vessels during the usage of handheld devices. As such, we recommend the use of two hands in handling digital devices in order to reduce the risk of musculoskeletal related problems.

#### **4.3 Musculoskeletal Symptoms Associated with Posture**

Barsawade, V., et al. [25] stated that sitting was the most frequent position using digital devices that could cause neck pain. In our study, sitting and semi-reclining positions were significantly associated with neck, upper and lower back discomfort. Asundi, Odell [26] found that laptop sitting promotes greater head down angle, viewing angle, wrist extension, and physical discomfort than those in personal computer sitting. It was reported that while sitting and bending the head forward, the weight observed by the spine significantly increases causing the loss of normal curvature and an increase in stress around the neck and shoulder [11]. With improper postures such as bending forward (not sitting up straight) and sitting in one place for at least 1.5 hours with little movements may worsen the symptoms. In such a situation, university students can be advised to reduce discomfort involving neck, upper and lower back by practicing ergonomic sitting position while using digital devices.



#### **4.4 Musculoskeletal Symptoms Associated with Time Spent using Digital Devices**

University students in our study spent an average of 7.5 hours a day using digital devices in a sitting position. The long duration hours of digital devices use were constantly linked with musculoskeletal symptoms [27]. The longer the usage of devices usually give rise to shoulder, hand, upper and lower back discomfort [28]. These findings could be explained by the muscle overuse. Physical discomfort often occurred due to an overuse of muscle fibres causing damage at muscle cell level, which is also known as the Cinderella hypothesis [29].

In our study, time spent on handheld devices (mobile phone and tablet) significantly gave rise to musculoskeletal symptoms. Time spent on mobile phone affects mainly at shoulder, hands, upper and lower back region, but not at the neck. Time spent on tablet affects only at hands and upper back region. Findings from Shan, Deng [13] reported a significant relationship between tablet usage with neck and shoulder pain. A slightly different finding especially effect on the neck could be due to respondents' inability to differentiate the actual locality of the pain. There is no clear discrimination line between the neck and upper back pain.

While handheld devices were significantly correlated with musculoskeletal symptoms, we found that time spent on personal computer have no significant correlation with musculoskeletal symptoms. Similar to the study done by Diepenmaat, Van der Wal [30] they reported the lack of significant between desktop time usage and musculoskeletal symptoms. This could be because personal computer is more flexible to provide comfort to the users because personal computer can be arranged in suitable corner of the table with comfortable chair. This can reduce the risk of discomfort and musculoskeletal symptoms. However, other studies reported conversely where there is correlation between personal computer time usage and musculoskeletal symptoms. Personal computer also reported to increase the occurrence of lower back pain, shoulder and neck pain [17, 31, 32].

#### **4.5 Musculoskeletal Symptoms Associated with Eye-to-Screen Distance**

Additionally, the incidence of neck and shoulder pain showed significantly increased due to the posture and eye to screen distance while using a handheld device [13]. Since tablet devices are mobile, the postures that have been associated with the mobile phone can be co-related. In the present study, about 75% respondents reported to have unhealthy eye-to-screen distance. The healthy range of eye-to-screen distance for the mobile and tablet is 10 cm to 20 cm and for personal computer is 20 cm to 30 cm. Our study also found a significant positive relationship between eye-to-screen distance with neck, shoulder, lower and upper back symptoms. In this situation, heavy digital devices users, like university students, should be informed on maintaining a good eye-to-screen distance to prevent over-bending of the neck to look at the screen.

#### 4.6 Study Strengths and Limitations

The findings of this study should be interpreted with caution due to some limitations. This study faces constraints to achieve the minimum sample size of 343. Firstly, working on 311 samples (short by 32 samples), the margin of error has increased from 5.00 % to 5.60%. However, in social science study, a precision of 94.4% would have minimal effect on the Type I error rate (rejecting a true null hypothesis). Secondly, the sample was taken only from one university in Sarawak, thus generalisation of the finding is limited. Participants may not be representative of the target audience that the results are being applied to.

### 5 Conclusion

The university students (and students in general) are at a higher risk to experience musculoskeletal symptoms mainly on the neck, shoulder, hands, upper and lower back. Musculoskeletal symptoms tend to be higher among female students. These symptoms were significantly correlated with longer time spent on using digital devices mainly on sitting position, early age of using digital devices, and unhealthy eye-to-screen distance. Another risk for musculoskeletal symptoms is on a habit to hold the handheld devices with a single hand and a single thumb to operate. If these musculoskeletal symptoms are not prevented, it may cause more severe consequences. For example, symptoms on the neck could lead to cervical spondylosis and cervical nerve impingement affecting the upper limb dysfunction and disability. Consequences on the back symptoms may cause thoracic kyphosis, lumbar spondylosis and lumbar nerve impingement affecting the lower limb dysfunction and disability. Individuals who preferred to operate their handheld devices using a single thumb may develop flexor tenosynovitis. To mitigate musculoskeletal symptoms due to the usage of handheld digital devices, some form of health promotion initiative needs to be implemented in the university. Specific knowledge on sitting position (e.g. changing sitting position in every 1 hour), the importance of body stretching, proper neck posture and proper hand positions in handling the handheld devices need to be introduced to university students.

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