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Comparison of neck muscle strength, range of motion, and craniovertebral angle among Malaysian young adults using different electronic devices

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ABSTRACT

Aim: Prolonged use of electronic devices (EDs) and adopting poor posture during ED usage might lead to musculoskeletal disorders among young adults and adolescents. Hence, this study compares neck muscle strength, range of motion (ROM), and craniovertebral angle (CVA) among Malaysian young adults using different EDs.

Methods: A cross-sectional study using a quantitative study design was applied to compare neck muscle strength, ROM, and CVA between laptop and tablet users of Malaysian young adults. The population of this study covers young adults residing in Selangor, Malaysia. Among them, 30 laptop users and 30 tablet users were selected using the selection criteria and criterion-based sampling method. The data analysis was carried out with SPSS 20.0 at a 5% level of significance.

Results: There was no significant difference between the laptop and tablet users concerning neck muscle strength and CVA. However, a significant difference was observed only in the neck extension ROM between laptop and tablet users. The mean neck extension ROM is lower in tablet users than in their counterparts. The mean CVA of laptop and tablet users was less than 50 degrees, indicating severe FHP. Most laptop users (73.3%) were categorized into severe FHP than tablet users (53.3%).

Conclusion: The mean neck extension ROM is lower in tablet users than in laptop users. Most laptop users had severe FHP than tablet users. Hence, Malaysian young adults should adhere to the appropriate duration of ED usage, ergonomics while using ED. and postural correction exercises to prevent and reduce musculoskeletal problems.

Keywords: craniovertebral angle, electronic devices, Malaysian young adults, muscle strength, neck, range of motion

INTRODUCTION

Electronic devices (EDs) such as computers, laptops, tablets, and phones are becoming more ubiquitous in the workplace and at home [1]. The Internet, mobile device, and social media usage among the world population are 61%, 67%, and 56.8%, respectively. Young adults and adolescents observed a high predominance of device use [2]. In Malaysia, most young people utilize the internet for personal purposes, which include communication by text (96.3%), social networking sites (89.3%), gathering information (86.9%), and listening to music or online radio (72.7%) through their ED.

Moreover, prolonged use of EDs and adopting poor posture during usage might contribute to musculoskeletal impairments among young adults and adolescents [2]. Especially, 60.63% of electronic gamers in Malaysia had a forward head posture (FHP) [3]. A recent study stated that laptop users worked in much more extreme positions than desktop users, resulting in postural discomfort [4]. Another study observed that using a tablet resulted in more forward shift and neck flexion, irrespective of whether the tablet was held in the hands or supported on a table [5].

A previous study analyzed the effect of prolonged tablet computer usage with head forward and neck flexion posture on neck pain, cervical joint position sense, and balance control in subjects with mechanical neck pain [6]. Smartphone users with neck pain are prone to muscle fatigue, reduced pressure pain threshold and cervical range of motion (ROM) [7]. Alshahrani et al. concluded that the prolonged use of smartphones might affect cervical muscle endurance and grip strength in healthy college students at a Saudi university [8]. An earlier study

compared the cervical ROM and cervical flexion-relaxation ratio among computer users in Korea [9]. Another study revealed the occurrence of cervical extension deficit due to the overuse of smartphones among young adults in India [10]. Akodu et al. assessed the relationship between smartphone addiction levels and craniovertebral angle (CVA) among physiotherapy graduates in a Nigerian university. A high smartphone addiction level decreases CVA and increases scapular dyskinesis [11]. Furthermore, a more recent study observed a significant relationship between smartphone addiction, CVA (FHP), and neck disability. There is a higher prevalence of smartphone addiction among physiotherapy students in India, leading to FHP causing neck disability [12].

Regarding the Malaysian context, ED usage was directly associated with medical student's academic performance in a Malaysian university [13]. However, it failed to measure the neck symptoms in those ED users. Another study in Malaysia revealed a positive relationship between smartphone usage and the prevalence of neck and upper extremity symptoms among university students [14]. A recent study analyzed the incidence of musculoskeletal disorders (MSDs) and the level of smartphone addiction among university students in Malaysia. Smartphone addiction is positively associated with the incidence of MSDs with neck showed the highest occurrence of MSDs [15]. A review conducted by Malaysian researchers concluded that prolonged smartphone use would result in neck pain and MSDs [16]. While reviewing the past literature, several researchers have studied the neck symptoms such as pain, muscle strength, endurance, ROM, and CVA among smartphone, laptop, and tablet users. Notably, those users were mainly students as the study population. However, studies have yet to compare the neck muscle strength, ROM, and CVA between laptop and tablet users, especially in the Malaysian context. As the usage of ED is common among young adults, this study intends to compare neck muscle strength, ROM and CVA among Malaysian young adults using different EDs.

METHODOLOGY

Study Design

A cross-sectional study using a quantitative study design was used to compare neck muscle strength, ROM, and CVA between laptop and tablet users of Malaysian young adults.

Subjects

The young adults living in Selangor, Malaysia, were considered the population for this study. Among them, 30 laptop users and 30 tablet users were included using a criterion-based sampling method. The sample size was calculated using G-power 3.1 software and was observed as 30 subjects of each group with 80% power at an alpha of 0.05. Further, the inclusion criteria include young adults aged between 18 and 29 years old, those who use ED, either tablet or laptop for at least six hours per day and those who use tablet or laptop for at least 80% compared to other devices. The participants were excluded if they had history of cervical fracture or trauma, cervical surgery, functional or structural scoliosis, excessive thoracic kyphosis, acute neck pain, recent neck injury (including Whiplash associated disorder or concussion) in the last six months, neurologic disorders, or chronic obstructive pulmonary disease, and those who are athletes since their neck muscles are stronger than non-athletes.

Demographic information and an informed consent form were obtained from the selected subjects using a Google Form. The assessment procedures were explained to the subjects, and the data were collected using the appropriate measurement tool.

Outcome Measures

Neck muscle strength

The neck muscle strength was measured using a hand-held dynamometer (HHD) (JTECH Medical Commander Echo MMT) in neck flexion, extension, bilateral lateral flexion, and rotation. It is measured for three times during each movement in kilograms, and the average among three attempts was recorded. HHD showed high reliability in measuring neck muscle strength in all neck positions [17].

Neck range of motion

A universal goniometer was used to evaluate neck ROM of neck flexion and extension, right/left lateral flexion, and right/left rotation. Each movement was measured in degrees for three times, and the average among three attempts was recorded. This device showed excellent intra-rater and inter-rater reliability in measuring ROM [18].

Craniovertebral angle

The photogrammetry method was used to measure CVA, showing a reliability of >0.972 [19]. In this method, the pictures of subjects were captured from a lateral view with the camera (iPhone 13 camera) fixed on a tripod and 30 cm apart from the line denoting a subject's position. After the picture was taken, the collected photos were imported into Web Plot Digitizer software to compute CVA, and a virtual line was created from the middle of the tragus to the C7 spinous process, as well as a horizontal line through the C7 spinous process. Then, the subjects were classified into three groups such as minimal or non-FHP (≥55°), moderate FHP (50°-54°), and severe FHP (<50°), based on the interpretations according to CVA [20].

Data Analysis

The data was analyzed using SPSS version 20. Descriptive statistics were applied to reveal the subjects' demographic characteristics. An independent t-test was employed to compare the neck muscle strength, ROM, and CVA between laptop and tablet users. The level of significance was fixed as 0.05.

RESULTS

Demographic Characteristics

46.6% of laptop users were between 21 and 25 years, whereas most tablet users (60%) were aged above 25 years. Both groups of users showed an equal gender distribution. Further, the group was assigned to the BMI categorization system based on the ASIAN standard [21, 22]. Most laptop users (73.3%) were observed within normal weight ranges, whereas only 6.7% were underweight. Among tablet users, 53.3% had a normal BMI, and 13.3% were underweight (**Table 1**).

Furthermore, most laptop users (66.7%) were students, and only 6.7% were healthcare workers (HCWs). Among tablet

Table 1. Demographic characteristics

Categories		Laptop users (n=30) (n[%])	Tablet users (n=30) (n[%])	Total (n=60) (n[%])
Age	≤20 years	8 (26.7)	-	8 (13.4)
	21-25 years	14 (46.6)	12 (40.0)	26 (43.3)
	>25 years	8 (26.7)	18 (60.0)	26 (43.3)
Gender	Female	16 (53.3)	16 (53.3)	32 (53.3)
	Male	14 (46.7)	14 (46.7)	28 (46.7)
BMI	Underweight	2 (6.7)	4 (13.3)	6 (10.0)
	Normal	22 (73.3)	16 (53.4)	38 (63.3)
	Overweight	6 (20.0)	10 (33.3)	16 (26.7)
	Obesity	-	-	-
Occupation	Academic worker	4 (13.3)	6 (20.0)	10 (16.7)
	Business	-	8 (26.7)	8 (13.3)
	Health care worker	2 (6.7)	4 (13.3)	6 (10.0)
	Insurance agent	-	6 (20.0)	6 (10.0)
	IT worker	4 (13.3)	-	4 (6.7)
	Student	20 (66.7)	6 (20.0)	26 (43.3)
Hours using ED	6-8 hours	18 (60.0)	14 (46.7)	32 (53.3)
	>8 hours	12 (40.0)	16 (53.3)	28 (46.7)
Posture while using ED	Slouched sitting	30 (100.0)	18 (60.0)	48 (80.0)
	Slouched standing	-	12 (40.0)	12 (20.0)
	Correct sitting	-	-	-
	Lying	-	-	-
Purpose of using ED	Academics	20 (66.7)	6 (20.0)	26 (43.3)
	Work	10 (33.3)	24 (80.0)	34 (56.7)
	Social media	-	-	-
	Gaming	-	-	-

Table 2. Neck muscle strength

Variables	Laptop users	Tablet users	p-value
	Mean±Standard deviation (in kilograms)	Mean±Standard deviation (in kilograms)	
Flexion	3.76±0.86	4.18±0.96	0.696
Extension	4.55±0.48	4.80±0.84	0.730
Right lateral flexion	4.27±0.73	4.61±0.94	0.222
Left lateral flexion	4.23±0.69	4.69±1.05	0.070
Right rotation	3.92±0.65	3.81±0.73	0.646
Left rotation	3.87±0.57	3.87±0.69	0.806

users, 26.7% were businesspeople, 13.3% were HCWs, and the remaining were observed as academic workers, insurance agents, and students, with a distribution of 20% each. Concerning the hours of ED usage, 60% used a laptop for six-eight hours, and 53.3% used a tablet for more than 8 hours. While analyzing the posture adopted during ED usage, all laptop users adopted slouched posture, and 60% of tablet users adopted slouched posture. Concerning the purpose of using ED, most laptop users (66.7%) used their laptops for academic purposes, and 80% of tablet users used their tablets for work (**Table 1**).

Neck Muscle Strength

The results showed no significant difference in neck muscle strength between laptop and tablet users ($p>0.05$). The tablet users had a higher mean score of neck muscle strength in flexion, extension, and right and left lateral flexion than laptop users. In contrast, laptop users showed a higher mean neck muscle strength in the right rotation than their counterparts. However, the mean neck muscle strength in the left rotation was identical in both groups (**Table 2**).

Neck Range of Motion

There was a significant difference in the neck extension ROM between laptop and tablet users ($p<0.05$). The mean neck extension ROM is lower in tablet users than in laptop users. However, there was no significant difference between laptop and tablet users concerning the ROM of neck flexion, right and left lateral flexion, and right and left rotation ($p>0.05$) (**Table 3**).

Craniovertebral Angle

No significant difference was observed in CVA between laptop and tablet users ($p>0.05$). Both groups showed the presence of severe FHP (CVA<50); however, the mean CVA is slightly lower in laptop users than in tablet users (**Table 4**).

Based on CVA measurements, most laptop users (73.3%) were graded with severe FHP when compared with tablet users (53.3%) (**Table 5**).

DISCUSSION

This study compared neck muscle strength, ROM, and CVA among Malaysian young adults using different ED users. 46.6% of laptop users were between 21 and 25 years, whereas 60% of tablet users were above 25 years. Further, an equal gender distribution in both groups, which is contrary to the findings of a previous study [23]. 60% of laptop users used their laptop for six-eight hours. 53.3% of tablet users used their tablet for more than eight hours. These findings accord with an earlier study, which revealed that 35.21% of college students used their EDs for four-six hours, and 18.31% used them for seven-nine hours [24].

Table 3. Neck range of motion

Variables	Laptop users	Tablet users	p-value
	Mean±Standard deviation (in degrees)	Mean±Standard deviation (in degrees)	
Flexion	34.53±6.56	31.60±6.48	0.995
Extension	39.40±3.79	36.87±5.84	0.012*
Right lateral flexion	32.93±6.57	36.60±6.22	0.803
Left lateral flexion	32.73±6.54	33.47±4.93	0.418
Right rotation	52.13±8.93	46.60±12.00	0.186
Left rotation	50.40±11.42	50.07±11.41	0.994

*Significant at 0.05 level

Table 4. Craniovertebral angle

Variables	Laptop users	Tablet users	p-value
	Mean±Standard deviation (in degrees)	Mean±Standard deviation (in degrees)	
Craniovertebral angle	47.00±6.76	48.82±8.34	0.401

Table 5. Categorization of FHP among subjects based on CVA

Variables	Laptop users (n[%])	Tablet users (n[%])
Minimal FHP	4 (13.3)	8 (26.7)
Moderate FHP	4 (13.3)	6 (20.0)
Severe FHP	22 (73.4)	16 (53.3)

Computer usage predicted adverse changes in sleep duration and bedtimes on school days and weekends [25]. Besides, this study observed that most laptop users (66.7%) were students compared to tablet users. Similarly, it was found that 88% of university students used laptops [26]. All laptop users adopted slouched sitting posture, and 66.7% used laptops for academic purposes. A previous study also concluded that 52% of students used laptops in slouching forward posture for academic purposes [27]. Slouching is an awkward posture for young adults and leads to increased compression on the spinal discs [28]. 60% of tablet users adopted slouched sitting posture, and 80% used tablets for work. Previous studies found that 48.3% of university students used tablets, and 25.4% of university students and staff used tablets in sitting without back support [29, 30].

Moreover, the results showed no significant difference in neck muscle strength between laptop and tablet users. Likewise, a recent study found no statistically significant difference in maximal voluntary contraction force of the neck muscles when comparing laptop and computer users of the same gender [4]. It is evident that the type of ED does not affect the neck muscles' capacity to generate force. However, this study also observed that laptop users had a lower mean score for neck muscle strength of flexion, extension, and right and left lateral flexion than tablet users. In contrast, laptop users had a higher mean neck muscle strength of right rotation than tablet users. Both groups had the same mean neck muscle strength of left rotation. This finding might be because laptop users adopt poor postures during work compared to desktop computer users, thereby resulting in postural strain [4]. Most laptop users of this study showed severe FHP compared to tablet users. Such posture increases the length of the external moment by progressing the head (gravitational center) forward of the load-bearing axis. The constant load on the neck extensors and noncontractile structures lead to the pathomechanical stress, which can result in musculoskeletal damage [31]. Also, prolonged FHP could lead to a reduced count of sarcomere and shortening of the muscle fibers, which impact muscle contraction [32]. Concerning tablet usage, the neck bends more while using a small screen rather than a large screen device. In response, the extensor muscles are activated to balance the neck, thereby raising the load on the cervical erector spinae and trapezius muscles [33, 34].

Besides, no significant difference was observed between laptop and tablet users in neck flexion, right and left lateral flexion, and right and left rotation ROM. However, there was a significant difference in the neck extension ROM between laptop and tablet users. Tablet users showed lower neck extension ROM than laptop users. This reduced extension may be due to the prolonged neck flexion occurring when the tablet is held either flat on a desk or below eye level. Such a condition may result in elongated neck extensors and exert more load on the musculoskeletal structures of the neck region [34]. Further, neck flexion postures cause an increase in gravitational load moment and neck extensor muscle activity, thereby causing neck extensor strain and neck pain [35]. Notably, a recent study discovered that users of tablets and laptops had more neck flexion, which increased postural strain. Hence, both users should adopt appropriate strategies to reduce exposure to awkward neck postures [36].

Regarding the CVA scores, most laptop users (73.3%) were graded with severe FHP (i.e., CVA<50) than tablet users (53.3%). However, there was no significant difference in CVA between laptop and tablet users. Laptop and tablet users demonstrated severe FHP with a mean CVA score of 47 and 48.82 degrees, respectively. In accordance with these findings, Saied et al. observed a significant decrease in craniocervical 3D angle for the laptop sitting style [37]. Also, a significant negative relationship was detected between CVA and laptop usage duration among university undergraduates. Those with lower CVA were long-term laptop users [38]. Furthermore, this study observed that 60% of laptop users used their laptops for six-eight hours, and all laptop users used their laptops in a slouched sitting posture. Laptops are designed with a screen attached to the keyboard; hence, the appropriate screen height is deliberately lower than the recommended one for computer use [39]. This condition results in prolonged neck flexion with consequent higher activity in the cervical erector spinae and upper trapezius muscles with a posture in which the trunk is slightly inclined backward [40]. It also leads to a consequent forward head and trunk flexion adopted as a fixed habitual posture [38]. Besides, CVA is affected by tablet position and usage. Children using tablets for three-six hours per day significantly decreased CVA with severe FHP than those using tablets for less than three hours per day [40]. This study found that 53.3% of tablet users were using their tablets for more than eight hours, and 60% were using their tablets in a slouched sitting posture.

Furthermore, adopting forward position of the head during smartphone usage reduces the lower cervical lordosis and forms a posterior curve in the upper thoracic spine to maintain balance. It leads to FHP, which places more load on the neck extensors and connective tissues [11]. Besides, FHP is associated with upper crossed syndrome. It reduces the average muscle fiber length contributing to extensor torque at the atlanto-occipital joint. This shortening lessens the tension-generating capabilities of muscles [38]. Postural changes in the neck (i.e., FHP) are linked to the neck pain, the lower maximal voluntary contraction of neck extensors and reduced neck active ROM [41-43].

This study is limited to a small sample size of Malaysian young adults. Further research should be conducted with a larger sample size to generalize the findings in the Malaysian young adult population. Gender differences in neck muscle strength, ROM, and CVA can be revealed in future studies. Furthermore, electromyography can be applied to analyze muscle activity during ED usage in various postures.

CONCLUSION

This study adds value to the existing literature by comparing the neck muscle strength, ROM, and CVA between laptop and tablet users of Malaysian young adults. It is observed that 60% of subjects used a laptop for 6-8 hours, and 53.3% used a tablet for more than 8 hours. All laptop users and 60% of tablet users adopted a slouch sitting posture. No significant difference between laptop and tablet users concerning neck muscle strength. However, a significant difference was observed only in the neck extension ROM between laptop and tablet users. The mean neck extension ROM is higher in laptop users than in their counterparts. Concerning the CVA, there was no significant difference between laptop and tablet users; nevertheless, the mean CVA is slightly lower in laptop users. Laptop users (73.3%) were mostly graded with severe FHP (CVA<50) when compared to tablet users (53.3%). It is recommended that Malaysian young adults should adhere to the appropriate duration of ED usage, adopt proper ergonomics while using ED, and regularly practice postural correction exercises to prevent and eliminate musculoskeletal problems.

Author contributions: VKP & YM: data acquisition; **SGS:** proposed conception & design of study; **AVS & SP:** collected relevant literature & edited original manuscript draft; **& PRM:** analyzed & interpreted data. All authors have agreed with the results and conclusions.

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Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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