Rocz Panstw Zakl Hig 2022;73(2):221-229
http://wydawnictwa.pzh.gov.pl/roczniki_pzh/ https://doi.org/10.32394/rpzh.2022.0210

ORIGINAL ARTICLE

THE EFFECT OF LAYING DOWN POSTURE WHILE USING SMARTPHONE AMONG SCHOOL CHILDREN IN NAKHON SI THAMMARAT, THAILAND

Uraiwan Madardam[1,2], Siriluk Veerasakul[1,2], Shamsul Bahri Mohd Tamrin[3], Jittaporn Mongkonkansai[1,2]

[1]Department of Occupational Health and Safety, School of Public Health, Walailak University, Nakhon Si Thammarat 80161, Thailand
[2]Research Center of Workers Health, Walailak University, Nakhon Si Thammarat 80161, Thailand
[3]Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia

ABSTRACT

Background. Lots of children use the smartphone in lying down posture that is unappreciated posture. The postures of children while using a smartphone affect their musculoskeletal pain and can enhance Musculoskeletal Disorders (MSDs).
Objective. To study the effect of lying down posture while using smartphone among school children in Nakhon Si Thammarat, Thailand.
Materials and methods. This survey study employed a Descriptive Cross-Sectional Design. The population was Grade 1-6 students studying in a primary school in Nakhon Si Thammarat. There were 122 samples selected based on the Volunteer Sampling Technique under the written consent of the students' guardians. The research instruments employed in this study were: 1) Questionnaire adapted from Nordic Musculoskeletal Questionnaire asking musculoskeletal symptoms, 2) Posture Assessment using Kinovea Software to measure the angles of the muscle and postures during photo and video shooting of the smartphone users. The data were analyzed using descriptive statistics while Chi-square and Mann-Whitney U tests were used to test the mean differences.
Results. There is a significant difference at $p<0.05$ level in mean angles of the neck, trunk, shoulder, and lower arms when using smartphones in supine and prone postures. The correlation between smartphone usage postures and musculoskeletal symptoms at the head/neck, trunk, and upper arm are found significantly different at $p<0.05$ level. The statistically significant difference at $p<0.05$ level is also found in the differences of age, length of smartphone ownership, position when using smartphone, and length of a smartphone usage in lying down positions.
Conclusion. Smartphone usage in lying down positions of the participants can cause musculoskeletal pain especially in prone posture. It is recommended that guardians or relevant sectors have greater attention to smartphone usage among children to prevent their long-term musculoskeletal problems.

Key words: *lying down posture, smartphone, students*

INTRODUCTION

Nowadays, learning and acquiring knowledge is not limited only from textbooks or printed materials but technology also plays an important role in several aspects of our daily lives. People learn more from technology anytime and anywhere. Technology usage has been vastly introduced into classroom learning, especially during the epidemic situation of COVID-19. The form of teaching and learning has been changed into an online learning approach. Therefore, the smartphone is an important device for learners to promptly access online learning in the current situation. It was reported that the percentage of global smartphone use during the Covid-19 outbreak among Gen Z (those who were born after 1997) was 82%, whereas the Gen Baby boomers were only 43% [1]. In Thailand, a survey of smartphone usage revealed that the group of children and youths was the majority of smartphone users at the highest frequency (CD) and 73.9% of internet use was performed by children aged between 6-14 years [2]. Prolonged smartphone usage can cause several aspects of health problems such as eyesight, behavioral sleep problems [3, 4] mental health [5], specifical problems in musculoskeletal pain caused by faulty positions during smartphone usage.

Corresponding author: Jittaporn Mongkonkansai (ORCID: https://orcid.org/0000-0003-0647-2001), Department of Occupational Health and Safety, School of Public Health, Walailak University, Nakhon Si Thammarat 80161, Thailand, e-mail: mayja_29@hotmail.com

Numerous research studies reported that smartphone usage can cause MSDs problems affecting the head, neck, trunk, upper- and lower-limbs. The prolonged usage of smartphones with continual neck flexion can lead to an improper posture of the head at 33–45° flexion (50^{th} percentile angle) from vertical when using smartphones [6]. The muscle activity level of smartphone users with neck pain is slightly higher than those without neck pain [7]. An increase in the duration of upper back flexion can cause thoracic kyphosis [8]. When excessive thoracic kyphosis occurs, (>40° kyphosis) it will lead to neck and back pain [9]. Moreover, overuse of smartphones can result in tenosynovitis [10].

The finding in a smartphone usage survey among primary school students in Nakhon Si Thammarat indicated that the students vastly used smartphones in their daily lives. The characteristic postures of smartphone use are in different positions such as sitting, standing and, lying down. Furthermore, it was found from the student interview that the most common posture used is lying down position by reason of more relaxation and a longer period of usage than sitting position. According to *Mateus* et al. [11] who conducted the study of different characteristic postures e.g. desk sitting, sitting cross-legged, lying supine, lying prone and standing when using the computer, tablet, and smartphone among 5-year children, it was reported that sitting on a desk and standing positions are the safest postures, on the other hand, the greatest risk of the affected area is on neck-trunk. Moreover, it was found that the most affected areas of lying prone are neck and trunk, and for lying supine are the arm and wrist [12]. Several researchers reported a number of studies of smartphone usage among children, however, there are few studies on investigating the lying postures and their effects on the musculoskeletal system of smartphone users in that the lying position is a greater effect on muscle fatigue or discomfort than the sitting posture [13]. Specifically, the studies on smartphone usage among elementary school children are utterly limited. Additionally, a current problem of smartphone usage among children is increased and it can lead to short- and long-term effects on their musculoskeletal conditions. Therefore, the researchers were encouraged to examine the lying postures of smartphone users and their short-term effects of musculoskeletal pain on elementary school children in Nakhon Si Thammarat, Thailand.

MATERIALS AND METHODS

Study Design

This study employed a Descriptive Cross-Sectional Design. The population was Grade 1-6 students studying at a primary school in Nakhon Si Thammarat, Thailand. This study had been conducted under the official consent of Walailak University Human Research Ethics Committee no. WUEC-19-061-01.

Population and Samples

The population was Grade 1-6 students studying in an elementary school in Nakhon Si Thammarat who used a smartphone in lying postures for a period of at least 6 months. There were 122 samples selected based on Volunteer Sampling Technique. All research subjects were informed of the research participation under the written consent of their guardians.

Posture Assessment

The body postures were assessed using Kinovea Software with a validity of 0.79 and reliability of 0.99 [14] to measure the angle of muscles and postures during photo and 5-minute video shootings of smartphone users in lying positions. The assessment was conducted in 4 parts comprising head/neck, shoulder, trunk, and lower arms. Generally, flexion is elevation paralleling to the sagittal plane and abduction is an elevation in the frontal plane [15]. The details of measurement were adopted from research studies [13] on the following angle measurement definitions:

Neck — the neck segment (ear to shoulder) was defined as flexed if the ear was anterior to the shoulder marker, and extended if posterior (A).

Trunk — the trunk segment, an angle was considered flexed if the acromion process (shoulder) was anterior to the greater trochanter (hip), and extended if posterior and a horizontal plane in the prone position (B).

Upper arm — shoulder (glenohumeral), elevation was calculated as the angle between the upper arm upwards away from trunk segment (C). Shoulder internal rotation was calculated as the angle between the forearm segment and a sagittal reference plane (D).

Lower arm — elbow flexion/extension (inner elbow angle), and wrist flexion/extension was considered. Elbow flexion was defined as the angle between the forearm and upper arm (E). Wrist flexion was defined as the angle between the hand (F) segment and the forearm segment (sagittal plane). As shown in Figure 1 and Figure 2.

Musculoskeletal Pain

The questionnaire was designed to ask musculoskeletal pain that appeared on 4 parts of organ namely head/neck, trunk, upper arms (shoulder) and lower arms. The frequency of pain within the past six months was divided into five levels: *never*, *once in a month*, *once in a week*, *more than one time per week*, and *frequently in a week*. If the frequency of musculoskeletal pain appears over one time in a week, it can be interpreted according to Nordic

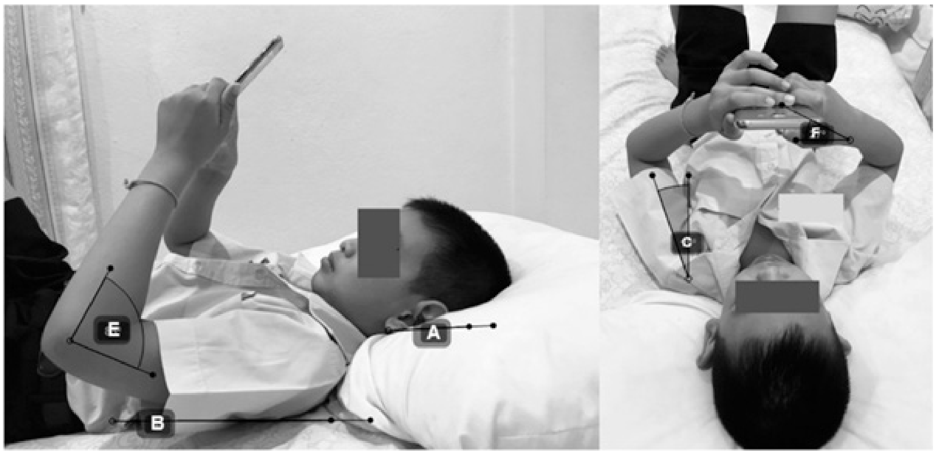

Figure 1. The posture assessment in the supine position

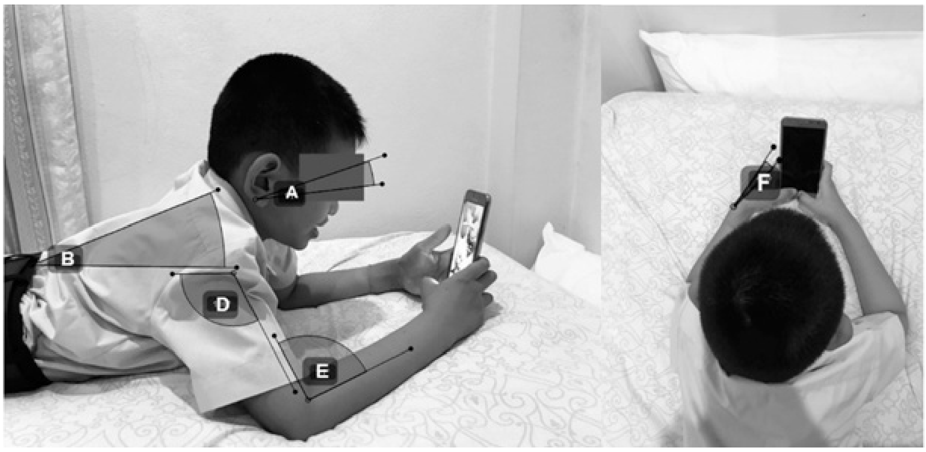

Figure 2: The posture assessment in the prone position

Musculoskeletal Questionnaire [16] that a student has a short-term effect of musculoskeletal pain.

Data analysis

This study utilized descriptive statistics to analyze the collected data in the aspects of smartphone usage, ergonomic risks, and frequency of musculoskeletal pain. The data were analyzed using frequency, percentage, mean, standard deviation, maximum and minimum values in inferential statistics, t-test for the analysis of the differences of mean angles, and p-value (below 0.05 were considered as statistically significant). The software used for statistical analysis was Microsoft Excel and SPSS version 21.

RESULTS

General information

The majority of the subjects were female students (65.6%) with an average age of 10.19±1.63 years old, 88.5% of them had no congenital disease, 89.3% of the students worked out regularly, 81.1% used their own smartphone, and an average length of smartphone use was 40.4±20.8 minutes per time, or 137.34±97.3 minutes per day. The most common size of smartphone use was 5.5 inches, 77.0% of parents set a rule for smartphone usage, and supine was the most common posture used during smartphone playing (68.0%).

Body Posture When Using a Smartphone

There are two lying down postures of the smartphone users—supine and prone with the following details of body postures.

Supine posture: The body angles of 82 smartphone users on supine position are as the following details:

Head/neck and Trunk: Head/neck is supported by a pillow. The angle of head/neck and trunk are paralleled to the floor. The body is symmetric aligned and sagittal reference plane is aligned.

Upper Arm: The shoulder movement was observed. Most of students have an average angle at 11.66±17.98 degrees of shoulder horizontal abduction. Forty percent (40%) of which has shoulder flexion at 22.84±20.20 degrees while using smartphones.

Lower Arm: There is 100% of smartphone users having elbow flexion at an average angle of 64.40±25.63 degrees, and 41.5% of them performed wrist radial deviation at 14.81±14.3 degrees.

Lying prone posture: The body angles of 40 smartphone users on prone position are as the following details:

Neck: It was found that 100% of the subjects perform neck extension at an average angle of 18.97 ± 13.46 degrees.

Trunk: The trunk extension at a median angle of 19.87±14.44 degrees is also observed

in all smartphone users (100%).

Upper Arm: For the upper arm angle, the smartphone users have elevated their upper arms with elbow supported or shoulder elevation at a median angle of 49.46 ± 41.67 degrees.

*Lower Arm***:** Considering the lower arms, the smartphone users have flexed their lower arms to the trunk with elbow flexion. The average angle is 58.08± 44.29 degrees, and 57.5% of the subjects perform wrist radial deviation at an average angle of 27.25±23.81 degrees.

Comparison of the mean angles differences of the body parts while using smartphones in lying down postures (n=122)

As shown in Table 1, the difference of mean angles of neck, trunk, upper arm (shoulder) in lying supine and prone postures while using smartphones was statistical significance (p<0.05).

Musculoskeletal pain appeared on various parts of body

There are 66.4% of smartphone users have a short-term effect on their musculoskeletal pain. The most common musculoskeletal pain found when using a smartphone in lying supine is at the lower arms

Table 1. Mean angles of body parts when using smartphones in lying postures

Body parts flexion/ extension	Posture (Mean ± SD)		p-value
	Supine	Prone	
Head/Neck	8.43±9.69	18.97±13.44	0.000*
Trunk	4.70±5.97	19.87±14.44	0.000*
Upper arm (shoulder)	11.66±17.98	49.46±41.67	0.000*
Lower arm	64.40±25.63	58.08±44.29	0.471

*p<0.05

Table 2. Musculoskeletal pain of various parts of the body (n=122)

Posture	Head/neck		Trunk		Upper arm		Lower arm	
	have	no	have	no	have	no	have	no
Supine	7(5.7)	76(62.3)	11 (9.0)	72(59.0)	29(23.8)	54(44.3)	42(34.4)	41(33.6)
Prone	33(27.0)	6(5.0)	30(24.6)	9(7.4)	31(25.4)	8(6.5)	16(13.1)	23(18.9)
p-value	0.000*		0.000*		0.000*		0.323	

Table 3. Comparison between different factors and durations while using smartphone in lying postures

Factor	Duration in lying posture mean±SD (min)	p-value [a]
Gender		
Male	141.8±98.11	0.430
Female	146.8±95.37	
Age		
≤ 10 years old	121.9±93.72	0.001*
>10 years old	168.2±93.22	
Smartphone ownership		
No	107.7±59.44	0.047*
Yes	153.7±100.84	
Family agreement on smartphone use		
No	174.0±120.18	0.081
Yes	134.6±84.22	
Postures using smartphone		
Supine	128.5±77.46	0.007*
Prone	180.3±120.40	

*p < 0.05, [a.] *Mann-Whitney* U test

(34.4%), followed by the upper arms (23.8%). In a lying prone posture, the musculoskeletal pain at head/neck, trunk, and upper arms are greater than lying supine posture. The most common pain when using the lying prone posture are found at head/neck, upper arms, and trunk (27.0%, 25.4% and 24.6% respectively). The correlation between postures and pain at head/neck, trunk, and upper arms is statistically significant ($p<0.05$). As shown in Table 2

Comparison of the differences between factors and durations of smartphone use in lying postures

As shown in Table 3, the difference of factors and lengths when using smartphone in lying postures is statistically significant ($p<0.05$). Different factors of age, smartphone ownership, smartphone usage posture, musculoskeletal symptom have different lengths of smartphone usage in lying positions.

DISCUSSION

Smartphone use in lying postures

Head/Neck

When using a smartphone in lying supine posture, head/neck and neck of smartphone users are paralleled to the axis of body symmetry. There is low-risk head/neck and trunk pain when using lying supine posture, specifically when head/neck is supported by a pillow. Whereas in a lying prone posture, all smartphones users have neck extensions. According to ISO 11226:2000 on Ergonomics-Evaluation of static working postures [17], over 25° neck extension is unacceptable as neck extension is found to correlate with the frequency of neck pain [18]. When texting on a smartphone, muscle activity in the neck-shoulder area of the users has increased resulting in musculoskeletal pain [19]. In this study, the student participants used their own smartphones; the duration of smartphone use is highly possible to be prolonged so that it is probably elevated smartphone users' long-term neck pain and become symptomatic adults.

Trunk

When using smartphones in lying supine posture, trunks of smartphone users and sagittal reference plane are paralleled to the floor. Whereas in lying prone posture, all the smartphones users have trunk extension. In this case, back chronic pain can be a long-term symptom. An imbalance in trunk muscle strength, i.e., extensor muscle strength is lower than flexor muscle strength; it might be one risk factor for low back pain [20]. According to the study of Steffen, it was found that all conditions in extension/flexion relating to lower truck peak torque cause back pain. Moreover, EMG amplitudes were increased for BP athletes with statistically significant differences for dorsal muscles in rotation and extension ($p< 0.0042$) [21]. From behavioral observation, while the students were playing with smartphones, it was found more back extension when they were playing games or enjoying interesting stuff in front of them. Sometimes they used elbows to support the trunks demonstrating utmost intention and concentration to use smartphones. It is congruent with *Hanphitakphong* et al. [22] who found that as the time participants spent playing the smartphone game increased, the trunk angle of the participants is greater ($p < 0.05$). The trunk angle of participants was approximately 14.05 ± 11.93 degrees at the start of the game, by the time passed, the angle was increasing to 19.83 ± 13.59 degrees (at 10 minutes) ($p < 0.05$), and 23.15 ± 15.61 degrees (at 20 minutes) ($p < 0.05$), respectively.

Upper arm

Lying supine playing a smartphone, shoulder horizontal abduction and shoulder flexion have been performed. As in the lying prone, the student participants elevated their upper arms with elbow support or shoulder elevation. In the study of fatigue of shoulder muscles at different cervical flexion angles (0°, 30°, and 50°) measured by electromyography, the result revealed that the right upper trapezius (RtUT), left upper trapezius (LtUT) showed the highest muscle fatigue at a cervical flexion angle of 50° and the lowest fatigue at an angle of 30° [23]. Similarly, a study conducted by *Straker* et al.[24] concluded that children who use tablets have greater trunk flexion with more shoulders flexion and elevation compared to desktop computer usage.

Lower arm

Elbow flexion is commonly found in lying supine and prone postures during smartphone playing. This is due to while playing smartphones, the participants compulsorily elevate their elbows to make it more convenient and clear on smartphone screen watching. As a result of this, lying supine playing a smartphone causes muscle tension as the participants have to upraise their elbows. Prolonged smartphone use can cause muscle fatigue and pain. This condition can be explained that during elbow flexion, the stretch of the ulnar nerve is 4.5 to 8 mm since it lies posterior to the axis of motion of the elbow and the cubital tunnel cross-sectional area narrows by up to 55%, as intraneural pressures increase up to 20-fold. As a result, recurrent and constant elbow flexion can irritate the ulnar nerve and finally lead to cubital tunnel syndrome [25]. More findings on the lower arm effect showed that wrist radial deviation has been found in both lying supine and prone postures as the participants would have more convenient to type and play games. The range of wrist postures is inclusive of wrist angles that is associated with low carpal tunnel pressure and is much lower than the angle (32.7°) that is correlated with high carpal tunnel pressure (more than 30 mm Hg) and it is a high-risk symptom of a carpal tunnel syndrome [26].

Comparison of mean angle differences of various body parts while using smartphones in lying postures

The finding from this study revealed that the differences of mean angles of head/neck, trunk, and upper arms were found statistically significant in lying supine and prone postures. When playing smartphones in a lying prone position, the mean angle of head/neck and trunk is higher than the supine posture. Whereas in a lying supine position, the mean angle of upper arms is greater than the prone one. It can probably explain that when the student participants play smartphones in the supine position, their head/necks and necks are normally on the pillows; trunks are paralleled to the floor. Therefore, head/neck and trunk angles in the supine position are lower than the prone one. Neck and trunk pain risks are consequently low in this posture.

Flores-Cruz et al. [27] found a similar result that head flexion was found lower in lying down condition than the sitting and standing ones. Likewise, *Dennerlein* [28] suggested that seating postures are more neutral when back support is sufficient. Therefore, a stool without a back support may produce a greater angle of head flexion compared to an office chair with ample back support. However, the mean angle of the upper arms in the supine position is greater than the prone. This is due to while playing smartphones in supine condition, the participants compulsorily elevate their arms, shoulders, and elbows to make it more convenient and clearer on smartphone screen watching. In the study of *Hanphitakphong* et al. [22], it was unveiled that spending longer duration with smartphone playing, shoulder and elbow angles are greater. This researcher found that the flexion angle of the left shoulder was significantly greater at 10 minutes 10.70 ± 11.89 degrees; $p < 0.01$) and 20 minutes (12.67 ± 12.60 degrees; $p < 0.001$) compared with baseline values (8.87 ± 10.86 degrees). Elbow flexion showed that as game time increased, the angle increasingly lifted on both sides. The bilateral elbow flexion angle was significantly greater at 10 minutes (Right 101.70 ± 11.44 degrees; $p < 0.001$ and Left 104.46 ± 12.07 degrees; $p < 0.001$) and 20 minutes (Right 102.37 ± 11.87 degrees; $p < 0.001$ and Left 105.86 ± 11.30 degrees; $p < 0.001$) compared with baseline value (Right 94.58 ± 10.30 degrees and Left 98.35 ± 12.75 degrees). The bilateral elbow flexion angle was significantly greater at 20 minutes ($p < 0.001$) compared with this value at 10 minutes [22].

Short-term effects of MSDs on smartphone users using lying postures

According to the findings, it was found that the student participants, who played smartphones on supine posture, have experienced the short-term effects of musculoskeletal pain. In this posture, the lower and upper arms are found to be the most common musculoskeletal pain. Considering the prone position, head/neck, upper arms, and trunk are reported the most affected areas of muscle pain. Additionally, the postures of smartphone users are found to significantly correlate with head/neck, upper arms, and trunk pain ($p<0.05$). The findings have been consistent with the differences of average angles of head/neck, trunk, and upper arms in prone positions which are higher than the supine ones when playing smartphones. In addition, in prone posture, the musculoskeletal pains have been found greater at head/neck, trunk, and upper arms than the supine condition. These could possibly be explained that using a smartphone in lying supine posture, head/neck and trunk are parallel to the floor with pillow support. Therefore the risk of head/neck and trunk pain is lower than using a smartphone in prone posture. The study of postures of smartphone users with head/neck and shoulder support revealed that the chair support (armrests and back support) reduced head/neck flexion ($p < 0.001$), gravitational moment ($p<0.001$), and muscle activity ($p<0.01$) in the neck and shoulder regions significantly compared to no chair support. These results indicate that biomechanical exposures leading to muscular pain in the neck and shoulders during mobile phone use can be diminished with sufficient and effective support of a chair [29]. In a similar way, plying smartphone in the prone position is associated with higher muscle activity in neck extension [19]. In this study, the participants spent an average of 40 minutes per time playing smartphones. *Hanphitakphong* et al. [22] suggested that a proper duration of smartphone playing for children aged 10 -18 years should not be over 10 minutes. An overuse of smartphones can cause biomechanical effects around the neck area. Relatedly, the upper arm muscles have been highly activated when excessive use is performed. There is a significant difference in upper limb muscular discomfort between two groups of low- and high-users ($P=0.033$) [30].

Comparison of the differences between factors and durations while using smartphones in lying postures

According to the comparison results between various factors and durations of smartphone use in lying postures, the difference of factors and lengths when using smartphones in lying postures is statistically significant ($p<0.05$). Different factors of age, smartphone ownership, smartphone usage posture, musculoskeletal symptom have shown different lengths of smartphone usage in lying positions. The student participants aged over 10 years have a longer duration of smartphone playing than those under 10 years. This is congruent with the prospective follow-up study of neck pain in school students aged between 10 to 15 and found that smartphone use was the most frequent activity among 10 years old children. An increase mostly occurred between the ages of 12 and 15. Negative effects caused by muscle pains have affected school achievement, emotional well-being, sleep behavior, and overall health and well-being [31]. It can be explained that in this study, the samples were upper-primary school children aged over 10 years who were in good physical condition and had more concentration than the children aged lower than 10, they therefore tend to spend more time on smartphone playing. Evidence of the study of Saxena et al. proposed that children have a lower pain threshold than adults [32]. According to *Wu* et al. [15], it was found that the difference in age of participants and game duration may lead to small differences in pain level. Considering at smartphone ownership factor, it was found that the users have different durations of playing if the smartphones belong to them. The children who use their own smartphones tend to play longer than those who do not. The result from the interview indicated that the non-smartphone owners did not carry their smartphones to school. For this group, they can play smartphone only on weekday's after-school time or on the weekends. In contrast with the smartphone owner group, they frequently played with their mobiles during break time or lunch time. In addition, the researchers noticed that there was also a rule for smartphone playtime set by parents of the participants. There is more playtime limitation for non-smartphone owners than the other group. Smartphones can be used for tasks whenever and wherever people need them. As a result, they allow people to evenly switch between multiple tasks on the move [33]. *Oulasvirta* et al. [34] found that when compared to laptop computer use, the smartphones is significantly shorter in duration, more seamlessly spread throughout the day, and less than twice the total time spent. In a comparison of lying posture and duration of smartphone playing, it was found that playing the phone in different lying positions has different durations of smartphone use. The result showed that a longer duration of smartphone use is frequently found in a prone position than in the supine one. This is opposite to the study conducted on Sleep Apnea patients and found that the participants use prone and supine patterns with a frequency of 0.8% and 55%, respectively [35]. However, the interview result in this present study indicated that the participants feel more comfortable in prone condition-using their hands and wrists more independently to control smartphones, placing their elbows to the floor, and have more and long concentration on the phones. Whereas in the supine position, there is elbow and shoulder elevation during smartphone use and it can easily lead to muscle fatigue. Evidence from the study also confirmed that the MSDs of lower arms has greater in lying supine than the prone condition.

CONCLUSION

Lying supine is the most common posture used among the children participants when using smartphones. However, using a smartphone in lying down affects the mean angles of the head/neck, trunk, and upper arms. Especially the mean angles of the head/neck, trunk, and upper arms in the prone position are higher than that of the supine one. Moreover, the postures of smartphone users are found to significantly correlate with head/neck, upper arms, and trunk pain. The Musculoskeletal pain of the head/neck, trunk, and upper arms of smartphone users in the supine position is higher than the supine posture. In addition, different factors of age, smartphone ownership, and postures have a significant difference in the duration of smartphone use in a lying position ($p<0.05$).

Acknowledgements
The authors are grateful to all the participants involved in this study and Walailak University for providing the support for this scoping review (WU-IRG-62-012).

Conflict of interest
The authors declare no conflict of interest.

REFERENCES

1. *Statista*. A Device usage increase due to the coronavirus worldwide 2020. Avaiable: https://www.statista.com/statistics/1106590/device-usage-coronavirus-worldwide-by-generation/#statisticContainer (Accessed 12 November 2021).
2. Nation Statistical Office. The 2019 Household survey on the use of information and communication teachnology. Avaiable: http://www.nso.go.th/sites/2014/DocLib13/full_report62.pdf (Accessed 13 November 2021).
3. *Ekinci Ö., Çelik T., Savaş N., Toros F.*: Association Between Internet Use and Sleep Problems in Adolescents. Noro Psikiyatr Ars. 2014;51(2):122-128. doi:10.4274/npa.y6751
4. *Twenge JM, Krizan Z, Hisler G.*: Decreases in self-reported sleep duration among U.S. adolescents 2009-2015 and association with new media screen time. Sleep Med. 2017;39:47-53. doi:10.1016/j.sleep.2017.08.013
5. *Elhai JD, Levine JC, Hall BJ.*: The relationship between anxiety symptom severity and problematic

smartphone use: A review of the literature and conceptual frameworks. J Anxiety Disord. 2019; 62:45-52. doi:10.1016/j.janxdis.2018.11.005

6. *Lee S, Kang H, Shin G.*: Head flexion angle while using a smartphone. Ergonomics. 2015;58(2):220-226. doi:10.1080/00140139.2014.967311
7. *Namwongsa S, Puntumetakul R, Neubert MS, Boucaut R.*: Effect of neck flexion angles on neck muscle activity among smartphone users with and without neck pain. Ergonomics. 2019;62(12):1524-1533. doi:10.1080/00140139.2019.1661525
8. *Middleditch A, Oliver J.*: Functional Anatomy of the Spine. 2nd Edition. Cambridge: Butterworth-Heinemann; 2005.
9. *Falla D, Jull G, Russell T, Vicenzino B, Hodges P.*: Effect of neck exercise on sitting posture in patients with chronic neck pain. Phys Ther. 2007; 87(4):408-417. doi:10.2522/ptj.20060009
10. *Ashurst JV, Turco DA, Lieb BE.*: Tenosynovitis caused by texting: an emerging disease. J Am Osteopath Assoc. 2010; 110(5):294-296.
11. *Xie Y, Szeto GP, Dai J, Madeleine P.*: A comparison of muscle activity in using touchscreen smartphone among young people with and without chronic neck-shoulder pain. Ergonomics. 2016;59(1):61-72. doi:10.1080/00140139.2015.1056237
12. *Ospina-Mateus H, Niño-Prada B, Tilbe-Ayola K, Contreras-Ortiz S,* (eds): Ergonomic and Biomechanical Evaluation of the use of Computers, Tablets and Smart Phones by Children. A Pilot Study. Singapore: Springer Singapore; 2017.
13. *Gold JE, Driban JB, Yingling VR, Komaroff E.*: Characterization of posture and comfort in laptop users in non-desk settings. Appl Ergon. 2012;43(2):392-399. doi:10.1016/j.apergo.2011.06.014
14. *Chheda P, Pol T.*: Effect of Sustained Use of Smartphone on the Craniovertebral Angle and Hand Dexterity in Young Adults. *IJSR*. 2019;8:1387-90.
15. *Wu G, van der Helm FC, Veeger HE*, et al:. ISB recommendation on definitions of joint coordinate systems of various joints for the reporting of human joint motion--Part II: shoulder, elbow, wrist and hand. J Biomech. 2005; 38(5):981-992. doi:10.1016/j.jbiomech.2004.05.042
16. *Dickinson CE, Campion K, Foster AF, Newman SJ, O'Rourke AM, Thomas PG.*: Questionnaire development: an examination of the Nordic Musculoskeletal questionnaire. Appl Ergon. 1992; 23(3):197-201. doi:10.1016/0003-6870(92)90225-k
17. International Organization for Standardization, ISO 11223: 2001 Ergonomics. Evaluation of static working postures, 2001.
18. *Kanchanomai S, Janwantanakul P, Pensri P, Jiamjarasrangsi W.*: Risk factors for the onset and persistence of neck pain in undergraduate students: 1-year prospective cohort study. BMC Public Health. 2011;11:566. Published 2011 Jul 15. doi:10.1186/1471-2458-11-566
19. *Xie Y, Szeto GP, Dai J, Madeleine P.*: A comparison of muscle activity in using touchscreen smartphone among young people with and without chronic neck-shoulder pain. Ergonomics. 2016;59(1):61-72. doi:10.1080/00140139.2015.1056237
20. *Lee JH, Hoshino Y, Nakamura K, Kariya Y, Saita K, Ito K.*: Trunk muscle weakness as a risk factor for low back pain. A 5-year prospective study. Spine (Phila Pa 1976). 1999;24(1):54-57. doi:10.1097/00007632-199901010-00013
21. *Mueller S, Stoll J, Cassel M, Engel T, Mueller J, Mayer F.*: Trunk peak torque, muscle activation pattern and sudden loading compensation in adolescent athletes with back pain. J Back Musculoskelet Rehabil. 2019;32(3):379-388. doi:10.3233/BMR-181215
22. *Hanphitakphong, P, Thawinchai N, Poomsalood, S.*: Effect of prolonged continuous smartphone gaming on upper body postures and fatigue of the neck muscles in school students aged between 10-18 years. Cogent Engineering, 2021; 8(1), 1890368. doi: 10.1080/23311916.2021.1890368
23. *Lee S, Lee D, Park J.*: Effect of the cervical flexion angle during smart phone use on muscle fatigue of the cervical erector spinae and upper trapezius. J Phys Ther Sci. 2015;27(6):1847-1849. doi:10.1589/jpts.27.1847
24. *Straker LM, Coleman J, Skoss R, Maslen BA, Burgess-Limerick R, Pollock CM.:* A comparison of posture and muscle activity during tablet computer, desktop computer and paper use by young children. Ergonomics. 2008;51(4):540-555. doi:10.1080/00140130701711000
25. *Chimenti PC, Hammert WC.*: Ulnar neuropathy at the elbow: an evidence-based algorithm. Hand Clin. 2013;29(3):435-442. doi:10.1016/j.hcl.2013.04.013
26. *Keir PJ, Bach JM, Hudes M, Rempel DM.*: Guidelines for wrist posture based on carpal tunnel pressure thresholds. Hum Factors. 2007;49(1):88-99. doi:10.1518/001872007779598127
27. *Flores-Cruz G, Sims VK, Whitmer DE.*: A Study on Head Flexion During Mobile Device Usage: An Examination of Sitting, Standing, and Lying Down Positions. Proceedings of the Human Factors and Ergonomics Society Annual Meeting. 2019;63(1):511-515. doi:10.1177/1071181319631047
28. *Dennerlein JT.*: The state of ergonomics for mobile computing technology. Work. 2015;52(2):269-277. doi:10.3233/WOR-152159
29. *Syamala KR, Ailneni RC, Kim JH, Hwang J.*: Armrests and back support reduced biomechanical loading in the neck and upper extremities during mobile phone use. *Appl Ergon*. 2018;73:48-54**.**
30. *Syamala KR, Ailneni RC, Kim JH, Hwang J.*: Armrests and back support reduced biomechanical loading in the neck and upper extremities during mobile phone use. Appl Ergon. 2018;73:48-54. doi:10.1016/j.apergo.2018.06.003
31. *Gustafsson ML, Laaksonen C, Aromaa M, Löyttyniemi E, Salanterä S.*: The prevalence of neck-shoulder pain, back pain and psychological symptoms in association with daytime sleepiness - a prospective follow-up study of school children aged 10 to 15. Scand J Pain. 2018;18(3):389-397. doi:10.1515/sjpain-2017-0166

32. *Saxena I, Kumar M, Barath AS, Verma A, Garg S, Kumar M.*: Effect of Age on Response to Experimental Pain in Normal Indian Males. J Clin Diagn Res. 2015;9(9):CC05-CC8. doi:10.7860/JCDR/2015/15385.6516
33. *Rogers Y, Connelly K, Hazlewood W, Tedesco L.*: Enhance learning: A study of how mobile devices can facilitate sensemaking. Pers Ubiquit Comput. 2010;14:111–124. doi: 10.1007/s00779-009-250-7
34. *Oulasvirta A, Rattenbury T, Ma L* et al. Habits make smartphone use more pervasive. Pers Ubiquit Comput 2012;16:105–114 . doi.10.1007/s00779-011-0412-2
35. *Ferrer-Lluis I, Castillo-Escario Y, Montserrat JM, Jané R.* Enhanced Monitoring of Sleep Position in Sleep Apnea Patients: Smartphone Triaxial Accelerometry Compared with Video-Validated Position from Polysomnography. *Sensors*. 2021; 21(11):3689. doi:10.3390/s21113689

Received: 10.02.2022
Accepted: 06.05.2022
Published online first: 28.05.2022