

Smartphone Usage Posture (Sitting and Lying Down) and Musculoskeletal Symptoms among school-aged children (6-12 years old) in Nakhon Si Thammarat ,Thailand

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Research

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Abstract

Background: The posture while using smartphone in school-aged children is at risk on occurring musculoskeletal symptoms. The purpose of this study is to study the postures while using a smartphone and the factors related to the abnormalities of the musculoskeletal symptoms of school-aged children.

Method: Experimental study is a method of this research. The samples were 233 school-aged children in Nakhon Si Thammarat, Thailand. Multi-stage sampling and data collection consisted questionnaire for the musculoskeletal symptoms by applying from the Nordic Musculoskeletal Questionnaire, ISO 11226: 2000 Ergonomics-Evaluation of static postures, which was a smartphone using posture evaluation form with data analysis using percentage, mean, standard deviation and Chi square.

Result: The smartphone usage posture are mostly a lying position, which is 52.4%. 91.5 % of children has unacceptable risky smartphone usage posture. Mostly, the lying position has various organs tilted at angles, compared to the body's symmetrical axis, rather than the sitting position. The school-aged children had a prevalence of musculoskeletal symptoms of 20.2%, with the lying position having a higher rate of musculoskeletal symptoms, which is 10.7%. The smartphone usage posture is statistically significant correlated with the symptoms occurring in the head area. The risk of ergonomics and the musculoskeletal symptoms are statistically significant.

Conclusion: The smartphone usage posture among students is at high risk especially lying position and has a chance of a musculoskeletal symptoms, higher than the sitting position. Educating to provide knowledge about safe use of smartphones to students, parents and relevant government agencies is very important.

Introduction

Smartphone or mobile phone considered as an important thing for the lives of modern people in order to communicate conveniently and quickly. In addition, newer model of smart phones has been developed to be more versatile and more efficient, making them accessible to all age groups, especially in elementary school children. Nowadays, children can easily learn via smartphone. The children were learning how to work out the solutions for themselves rather than by being "spoon-fed" by their teacher [1]. In Thailand, here is a trend of internet usage in children aged 6-14, increasing from 35.9% in 2010 to 69.6% in 2018. The screen times of the children internet users showed that 58.5% use internet 5-7 days per week and 40.2% use 1-4 days per week and most children spend 1-2 hours per day [2]. Almost all children (96.6%) used mobile devices, and most started using before age 1. Parents gave children devices when doing house chores (70%), to keep them calm (65%) [3].

However, although smartphones are useful in many ways for today's communication, research has shown that the children using a smartphone has both mental health, physical effects and academics effects at the same time [4] for example, depression and anxiety, social phobia or feelings of loneliness [5],[6],[7] and smartphone addiction [8]. Smartphone addiction among students is in the range of 24.8% –

27.8% and the trend of smartphone addiction in children increases every year [9]. Common problems found include eye problems such as dry eye, fatigue, headaches, eyestrain, presbyopia, etc [10], [11]. There are also problems with the musculoskeletal system in children who are addicted to smartphones and may develop faulty habitual posture due to constant neck flexion downward, which may place them at high risk of spine abnormalities. The international study reported flawed flexion of child neck and back while using smartphone [12], resulting in the prevalence of musculoskeletal pain was substantially high among school-adolescents [13], [14]. The study of Regina PF about the back posture in children, the result showed that children bent their back using smartphones in the range of 8.5-54 degrees and leaning backwards in the range of 12-24 degrees while on the screen. Both of these ranges are at risk for back and neck injuries [15]. The study of New York Spine Surgery and Rehabilitation Medicine found that flexing the neck 60 degree while using the phone is as same as applying 60-pound weight on the spine [16].

Preliminary survey found that there are many smartphones users among primary school children in Nakhon Si Thammarat province. The smartphone is used during the day, during a break time and after returning from school, in which these school-aged children use smartphone in both sitting and lying positions. Which can affect the musculoskeletal system, especially the upper limb. Other research will focus on the use of smartphones in sitting positions for adolescents and adults. However, the study of the use of smartphones in school-aged children, especially in lying positions, is still lack. Therefore, this research aims to study on the postures of school-aged children in Nakhon Si Thammarat, Thailand, while they are using a smartphone and musculoskeletal symptoms due to students' smartphones usage in a sitting and lying posture, in order to be used as information to prevent and resolve disorders and signs of musculoskeletal symptoms due to the use of smartphones in school-aged children.

Material And Method

1. Study design

This research was an experimental study of elementary students grade 1-6 in Nakhon Si Thammarat province, Thailand.

This research has been approved to conduct by Walailak University Ethics Committee on Human Research No. WUEC-19-061-01

2. Study population and procedure

The population was 308 students in elementary students grade 1-6 who have used smartphones for at least 6 months. The sample was a total of 233 elementary students grade 1-6 who have used smartphones for at least 6 months that agreed to participate in the project and obtained consent from their parents or guardians. This research was conducted between May 2019 - May 2020 by multi-stage sampling.

3. Research Instrument

The instruments used in the study consisted of 4 parts as follows

1. General information questionnaire concerning gender, age, education level, medical condition, exercising, surgical history, hobbies.
2. Questionnaire about smartphone usage, consisting of owning a smartphone, duration of smartphone usage (years), screen size, usage period per day, smartphone usage frequency, parents smartphone usage rules, smartphone usage postures.
3. The musculoskeletal symptoms are evaluated by modified Nordic Musculoskeletal Questionnaire [17] and body discomfort map, which divides the organs into 4 parts, consisting of the head, trunk, shoulders and upper arms and lower arms. The assessment conducted by students coloring in the affected area of the musculoskeletal symptoms. The frequency of symptoms within the past 3 months is divided into 5 levels: never, once a month, once a week, more than 1 time per week and frequently in a week. The criterion that gives a positive result on the musculoskeletal symptoms are students with symptoms ranging from more than 1 time per week, which is based on a survey about the health behavior of children of the World Health Organization [17].
4. Smartphone usage postures questionnaire by using Goniometer as a tool for measuring the movement angle of 4 organs, consisting of the head / neck, trunk, upper arm and lower arm of the students while using the smartphone in various gestures, which are sitting and lying and compare with the reference criteria from ISO 11226: 2000 Ergonomics-Evaluation of static postures [18]. This reference criterion has two levels of interpretations for each organ, which are acceptable and unacceptable. Researcher prepares a place or simulation device be suitable for the use of smart phones in students' daily life, consisting of chairs, sofas, mats, pillows, etc. While students demonstrate gestures using a smartphone, the researcher will assess the risk by taking photos and recording video for 5 minutes. For grade 1-2 elementary students or those who are not yet fluent in reading or do not understand the questions, the researcher interviewed them and adjusted the questions to be easier to understand by using the pictures and some additional information might be asked from the parents.

The questionnaire has tool quality testing with a conformance index between Index of Item – Objective Congruence (IOC) equal to 0.9.

5. Data Analysis

This study describes general information using descriptive statistical data on the use of smartphones, ergonomic risk and the prevalence of the musculoskeletal symptoms, consisting of frequency, percentage, mean, standard deviation, maximum, minimum. For inferential statistics, this research uses chi-square at 95% of confidence levels to describe relationships among variables and use SPSS version 21 program for data analysis.

Results

1. General Information

Most of the respondents were female (64.8%) with an average age of 9.95 ± 1.659 years, most had no underlying diseases (90.1%), exercising (87.1%), never having surgery in the past (93.1%), having a hobby (98.1%), most of them owning a smartphone (78.1%). The sample group of smartphone users has an average usage duration of 2.3 ± 1.458 years, the average screen size of the smartphone was 5.5 ± 0.890 inches, the period that most samples used smartphone was less than 30 minutes (48.5%) and average usage throughout the day was 138.39 ± 103.451 minutes per day. Most of the parents have rules about using smart phones with students (76.4%), the posture that school-aged children used while using a smartphone the most is a lying position (52.4%) as in Table 1.

Table 1. Descriptive data (n = 233)

General Information	Sample	Percentage
Gender		
Male	82	35.2
Female	151	64.8
Age		
Equal to or less than 7 years old	23	9.9
8 years old	27	11.6
9 years old	36	15.5
10 years old	49	21.0
11 years old	44	18.9
12 years old	54	23.2
± SD = 9.95±1.659 years, Max = 12 years, Min = 16 years		
Education level		
Grade 1 Elementary Students	17	7.3
Grade 2 Elementary Students	28	12.0
Grade 3 Elementary Students	30	12.9
Grade 4 Elementary Students	56	24.0
Grade 5 Elementary Students	38	16.3
Grade 6 Elementary Students	64	27.5
Medical condition		
Have	214	91.8
Do not have	19	8.2
Exercising		
Do not exercise	28	10.0
Exercise	205	90.0
- < 30 Minutes	125	61.0
- More than 30 minutes	80	39.0
Surgical history		
Never undergone surgery	224	96.1

General Information	Sample	Percentage
Had undergone surgery	9	3.9
Hobby		
Do not have	2	0.9
Have	221	98.1
- Planting	107	50.0
- Watching TV	92	39.5
- Reading	73	31.3
- Others	72	30.9
Smartphone owning		
Yes	51	21.9
No	182	78.1
Smartphone usage duration		
≤ 1 year	87	37.3
2-5 years	139	59.7
>5 years	5	3.0
± SD = 2.3±1.458 years, Max = 8 years, Min = 9 months		
Smartphone screen size		
< 6 inches	135	57.9
Bigger than 6 inches	98	42.1
± SD = 5.5±0.890 inches, Max = 8 inches, Min = 3 inches		
Usage periods (Per session)		
≤ 30 minutes	111	47.6
31 – 60 minutes	110	47.2
>60 minutes	12	5.2
± SD = 41.45±20.403 minutes, Max = 120 minutes, Min = 10 minutes		
Smartphone usage frequency (minutes per day)		
≤ 60 minutes	59	25.3
61-180 minutes	129	55.4

General Information	Sample	Percentage
>181 minutes	45	19.3
± SD = 140.36±101.6173 minutes/day, Min=15, Max=600 minutes/day		
Parents' smartphone usage rules		
Do not have	55	23.6
have	178	76.4
Smartphone usage postures		
Sitting	111	47.6
Lying	122	52.4

2. Ergonomic risk

An ergonomic risk assessment found that 91.9% of the students using smartphone have unacceptable postures and the postures do not correlate with ergonomic risk as details in Table 2.

Table 2. Ergonomic risk assessment (n=233)

Posture	Ergonomics risk (Percent)		
	Acceptable	Unacceptable	p-value
- Sitting position	106 (45.5)	5 (2.1)	
- Lying position	108 (46.4)	14 (6.0)	0.052
Total	214 (91.9)	9 (8.1)	

When examining the smartphone usage posture with various organs, it is found that the organs are mostly angled in the lying position by comparing with the body's symmetrical axis rather than the sitting position. Beginning with the head, most students (24%) bent their head over 25 degrees while they are in lying position. However, 72 percent did not have full head support in both sitting and lying position. As for the trunk part, students leaned their bodies forward for more than 20 degrees and most of them occurred in the lying posture for 19.3%, and 44.1% had no full support. On upper and lower arm, students' posture bent their upper arms less than 20-degree angle for 66.9% and bend more than 20 degrees in both sitting and lying position on lower arm. Furthermore, smartphone usage postures were significantly correlated to trunk angle and head angle at the statistical level at $p < 0.001$ as the details in the Table 3.

Table 3. Smartphone usage posture and body angles (n = 233)

Body angles	Sitting Position n(%)	Lying Position n(%)	
Head			
Less than 25 degrees	60(25.8)	66(28.3)	0.000**
25 degrees and above	51(21.9)	56(24.0)	
- Full support	0(0.0)	30(28.0)	
- Without full support	51(47.7)	26(24.3)	
± SD = 17.78 [□] ±13.869 [□] , Max = 60 [□] , Min = 0 [□]			
Trunk			
Less than 20 degrees	72(30.9)	77(33.0)	0.000**
20 degrees and above	39(16.8)	45(19.3)	
- Full support	17(20.2)	30(35.7)	
- Without full support	22(26.2)	15(17.9)	
± SD = 10.46 [□] ±11.585 [□] , Max = 50 [□] , Min = -40 [□]			
Upper arm			
Less than 20 degrees	77(33.0)	79(33.9)	0.454
20 degrees and above	34(14.6)	43(18.5)	
± SD = 20.89 [□] ±28.236 [□] , Max = 150 [□] , Min = -30 [□]			
Lower arm			
Less than 20 degrees	6(2.6)	15(6.4)	0.067
20 degrees and above	105(45.1)	107(45.9)	
± SD = 62.84 [□] ±29.565 [□] , Max = 160 [□] , Min = -5 [□]			
Head			
Less than 25 degrees	60(25.8)	66(28.3)	0.000**
25 degrees and above	51(21.9)	56(24.0)	
- Full support	0(0.0)	30(28.0)	
- Without full support	51(47.7)	26(24.3)	
± SD = 17.78 [□] ±13.869 [□] , Max = 60 [□] , Min = 0 [□]			
Trunk			

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20 degrees and above	105(45.1)	107(45.9)	
± SD = 62.84 [□] ±29.565 [□] , Max = 160 [□] , Min = -5 [□]			

3. The prevalence of musculoskeletal symptoms

School-aged children had 20.2% of the prevalence of musculoskeletal symptoms. The smartphone usage posture has no correlation with the prevalence of musculoskeletal symptoms as the details in Table 4.

Table 4. The prevalence of musculoskeletal symptoms (n=233)

Posture	Student with musculoskeletal symptoms (Percent)		p-value
	Have symptoms	No symptoms	
- Sitting Posture	22(9.5)	89(38.2)	
- Lying Posture	25(10.7)	97(41.6)	1.000
Total	47(20.2)	186(79.8)	

When considering the symptom level, most students do not have musculoskeletal symptoms and when inspecting parts of the body, it was found that the highest rate of symptoms occurred at the head part of

23 students (9.9%), which is about more than once a week. Smartphone usage posture were significantly correlated to head symptoms at the statistical level at $p < 0.05$ as the details shown in the Table 5

Table 5. Symptom Levels of various parts of the body (n=233)

Symptom Levels	Head	Trunk	Upper arm	Lower arm
No Symptoms	151(64.8)	196(84.1)	208(89.3)	204(87.6)
Once a month	36(15.4)	16(6.7)	10(4.3)	11(4.7)
Once a week	23(9.9)	15(6.4)	9(3.9)	12(5.1)
More than once a week	19(8.2)	5(2.1)	4(1.7)	5(2.1)
Often in a week	4(1.7)	1(0.7)	2(0.8)	1(0.5)
Total	233	233	233	233
Correlation with smartphone usage posture	0.048*	0.292	0.449	0.313

* $p < 0.05$

Ergonomic risk correlated with musculoskeletal symptoms significantly at the statistical level at $p < 0.031$ as the details shown in the Table 6

Table 6. Relevance between ergonomic risk and the musculoskeletal symptoms.

Ergonomics Risk	Student with musculoskeletal disorders (Percent)		p-value
	Have symptoms	No symptoms	
- Accepted	8(3.4)	11(4.7)	0.031*
- Unaccepted	39(16.7)	175(75.1)	
Total	47(20.2)	186(79.8)	

Discussion

1. Smartphone usage postures of the students

Most of the smartphone usage postures are in lying position with 91.5% ergonomics risk. Smartphone usage posture has a tendency to be associated with ergonomic risk. A study by Eardley et al. found that the lying posture had the most physical movement while using a smartphone, followed by sitting posture, which created a lot of movement, impact an increased risk of ergonomics [19]. From the interviews with the students, it was found that using smartphone in a lying posture would be more comfortable than

sitting and was able to use for longer. According to the study, the researchers found that using smartphone in the lying posture demonstrated the average time used approximately 10 minutes longer than the sitting posture (average duration of lying posture = 144.92 minutes / day, average duration of sitting posture = 135.35 minutes / day). Analyzing various parts of the body, the smartphone usage posture and head/neck and trunk's angles are interrelated with statistical significance. The study indicates that the angles of head, trunk, upper arm and lower arm while in the lying posture, are higher than the sitting posture. The average head and body bending were 17.78 and 10.46 degrees, which is consistent with the research of Pope, which found that the average body angle when using a smartphone is 25.58 degrees and the maximum back flexion/extension was 50 degrees [15]. Examining by the head angle, it is found that nearly half of all students stooped their heads in a sitting and lying position, and the important point is that using a smartphone in a sitting position does not have a full head support, which is at risk for the musculoskeletal system. The weight that is pressed on the head bones increases with neck flexion. A full-grown head weighs 5 kg in the neutral position. As the head bends forward, the weight seen by the neck increases to 18 kg at 30° and 27 kg at 60° [16]. However, even though the average angles of both head and trunk are in an acceptable range, smartphone usage in students exceedingly takes up to 40 minutes at a time and more than 2 hours per day, which indicated risk of musculoskeletal symptoms. Shan et al. found that students' usage of smartphone more than 2 hours / day of students correlated with the prevalence of lower back pain and neck and shoulder pain [20]. From upper arm angle, it is also found one of the parts that is in an acceptable level was upper arm. However, school-aged children who are using a smartphone lying down with the back to the floor, need to have their shoulders lifted up and abducted to be able to focus on the smartphone screen more clearly. Likewise, the angle of the lower arm, which the arms and elbows have to be lifted when using the smartphone in a lying posture. The wrists will twist towards the body to see the screen clearer. In the study, the average angle of the lower arm was equal to 63 degrees and the maximum is at 160 degrees, which is considered an unacceptable ergonomic risk. This is consistent with the study of Eardley et al who found that using smartphone while lying down with the back to the floor caused the upper arm and wrist move extremely [19].

2. The prevalence of the musculoskeletal symptoms

The students had the prevalence of musculoskeletal symptoms equal to 51.5%. Smartphone usage postures were irrelevant to the prevalence of musculoskeletal symptoms, which is in accord with the research of Palmer et al., he cited that there were 88% of discomfort when using mobile phone causing head / neck, back and shoulder symptoms without a trace of relation of smartphone usage and the discomfort of the body [21]. In addition, the study of [12] revealed the prevalence of head/neck (100%), trunk (61%), shoulders (69%) and arms symptoms (13%) while using smartphone respectively. When examined the various parts of the body, revealed that the students had head/neck symptoms as a highest rate and the smartphone usage postures were significantly correlated to head/neck symptoms at the statistical level at $p < 0.05$. This is consistent with the research of Hadidi et al., which found that students using smartphones have a high level (24%) of head / neck symptoms [22]. However, half of the students

bent down their head over 25 degrees and do not have full support while using smartphone, which means that the more time students spend on smartphones, the greater risk they have for the head symptom and other part of the body also. As well as the study of Yang, et al. and Areeudomwong et al. found that nearly half of the participants' experienced neck and shoulder discomfort and fatigue while texting on a touchscreen smartphone. Students who spend more than 3 hours per day on smartphones are more at risk of upper back pain than students who spend less than 1 hour per day (OR) = 4.23, $p < 0.05$. The stepwise regression results indicated that the number of body parts with discomfort ($F = 6.009$, $p < 0.05$) increased with hours spent using ancillary smartphone functions [23],[24].

In addition, if parents do not have disciplines or rules regarding the use of smartphones in students, it will have a detrimental effect on student health [25]. The World Health Organization has ranked neck pain and other musculoskeletal diseases as the fourth and tenth health problems, respectively [26]. Moreover, the elevated number of smartphone usage for communication may result in long-term neck pain due to prolonged periods of neck flexion [27], [28].

Conclusion

Most students lay down using their smartphones. The head, trunk, upper arm, and lower arm in the lying posture are tilted at angles more than the sitting posture, which has a high risk of ergonomics. In addition, symptoms of the trunk, upper arm and lower arm are found, especially the head/neck symptoms. The students verge to use the smartphones continuously increasingly[9]. Therefore, the protection of the health of students is important. Students, parents, school administrators and all relevant government agencies need to earnestly pay attention to the problem of student's smartphone usage in order to prevent the musculoskeletal symptoms in their span of ages.

Suggestions for students and parents

1. Avoid using the phone in the lying position.
2. Parents should have rules at home for using a smartphone, by limiting the using time of students to 20 minutes per time. After that, there should be physical exercises and eyesight.
3. School-aged children's smartphones should not be too small and should have at least 5 inches for a screen size.
4. School-aged children who are using smartphones should use a chair or sofa with the head, neck, body, and shoulders support.
5. School-aged children and parents should be provided with knowledge about the correct postures in using a smartphone.

Declarations

Ethics approval and consent to participate

This research has been approved to conduct by Walailak University Ethics Committee on Human Research No. WUEC-19-061-01

Consent for publication

All presentations of case reports have consent for publication.

Availability of data and materials

Data and material can available

Competing interests

No potential competing interest was reported by the authors

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Authors' contributions

Mongkonkansai J. completed the data analysis and developed the manuscript, Madardam U. and Veerasakul S. analyzed and interpreted the data and final prove.

Conflicts of interest

There are no conflicts of interest.

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