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Factors associated with neck disorders among university student smartphone users

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Abstract.
BACKGROUND: In our digital society, the use of smartphones has increased rapidly. Parallel with the growing use of smartphones, musculoskeletal problems associated with intensive smartphone use have also increased. Neck flexion is the most commonly adopted posture by smartphone users while looking at the visual display terminals of smartphones for extended periods; this posture may lead to neck disorders.
OBJECTIVE: The purpose of the current study was to investigate musculoskeletal disorders (MSDs) in smartphone users in Thailand in order to confirm high prevalence of neck pain. The study also aimed to determine all possible factors associated with neck disorders among smartphone users.
METHODS: A cross-sectional survey study was conducted with 779 undergraduate smartphone users. A self-administered questionnaire was used to collect self-report measures of smartphone use and musculoskeletal disorders. Descriptive statistics were used to analyze participant characteristics and the prevalence of musculoskeletal disorders. Logistic regression analysis was used to identify associated factors.
RESULTS: The most painful body region after the use of smartphones over a 12-month period was found to be the neck (32.50%). Factors associated with neck disorders were a flexed neck posture (Odds Ratio (OR): = 2.44, 95% Confidence Interval (CI) = 1.21–4.90) and smoking (OR 8.99, 95% CI 1.88–42.87).
CONCLUSIONS: The results suggest that to address neck disorders in smartphone users preventive initiatives should focus on reducing flexed neck postures and smoking.

Keywords: Prevalence, associated factors, neck flexion, smoking, pain

1. Introduction

In our digital society, the use of smartphones has increased rapidly. There are 3.4 billion smartphone users worldwide [1]. Thailand is nineteenth of the top twenty-five countries worldwide in terms of smartphone use [2]. The age group of smartphone users varies, ranging from students and workers in their 20s to senior citizens who are over the age of 60 [3]. University students in their 20s, in particular, use smartphones more than any other age group [4]. Compared to general cell phones, smartphones are very sophisticated devices, offering vast amounts of

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information and communication, all in the palm of your hand. They have an operating system, essentially making them palmtop computers, which are more powerful, provide greater computing capacity and diverse software applications [5]. Smartphones provide various conveniences, such as sending and receiving e-mail, accessing the Internet and engaging in entertainment, so the number of smartphone users has increased dramatically in recent years [6].

However, with the growing use of smartphones, comes concerns of increased musculoskeletal problems, which are associated with intensive smartphone usage. Musculoskeletal problems are among the most common occupational disorders in many countries and have an increasing trend [7]. An epidemiological study of 938 smartphone users conducted in the Republic of Korea found that 18.8% of smartphone users ($n = 185$) experienced musculoskeletal symptoms in at least one of their body parts [8]. In another Korean study involving 292 smartphone users, Kim et al. [6] found the most painful body regions from smartphones use were reported to be the neck (55.8%) and shoulders (54.8 %) [9].

The results of a different study conducted in Asia with a similar survey method are from Hong Kong, where musculoskeletal disorders among smartphone users were shown to have a much higher prevalence than the Korean study conducted by Eom et al. [8]. In the Hong Kong study, 70% of respondents reported having experienced neck pain ($n = 1{,}049$), 65% had shoulder pain, 46% experienced wrist and finger pain, [10]; the reasons for the difference in the study results from Korea and Hong Kong are not clear, however, there was a considerable difference in the sample size. Nevertheless, in Thailand, musculoskeletal disorders among smartphone users, especially in university students who are in their 20s, have not yet been reported.

Previous studies have shown the risk of musculoskeletal symptoms in information technology device users, such as tablet users, is related to personal factors such as gender (OR = 2.183, 95% CI [1.276, 3.736], $p = 0.004$) and awkward positions like sitting in a chair without back support (OR = 2.821, 95% CI [1.341, 5.934], $p = 0.006$) [11]. Both risk factors, gender and awkward postures, affected the prevalence of neck (84.6%) and upper back/shoulder (65.4%) musculoskeletal symptoms. While smartphone users have different usages compared with tablet users such as posture, previous studies which used self-report methods demonstrate four individual factors associated with musculoskeletal disorders in both groups. These factors were: (i) smartphone usage, people with higher smartphone use had more severe symptoms [12]; (ii) gender, females who use smartphones had a significantly higher neck disability index score than males ($p < 0.001$) [13]; (iii) age of user, older persons and (iv) lack of exercise also increased the occurrence of musculoskeletal disorders [10].

Physical design factors related to the smartphone itself may also lead to smartphone users developing musculoskeletal disorders. These physical factors have been reported in many survey studies, includes: the size of smartphone liquid crystal displays ($n = 292$) [9], the number of text messages (relative risk = 1.425) ($n = 983$), the time spent on daily usage of the smartphone (relative risk = 1.368) ($n = 2{,}353$) [4, 8] and prolonged static posture during smartphone usage ($n = 1{,}049$) [10]. Several studies have reported psychosocial factors associated with smartphone use. In Korea, Hwang et al. [12] surveyed the impact of smartphone overuse on upper extremity pain, anxiety, depression, and interpersonal relationships using several questionnaires (respectively: the Smartphone Addiction Inventory, the Musculoskeletal Symptom Checklist, the State-Trait Anxiety Inventory, the Beck Depression Inventory-II, and the Relationship Change Scale). They received 525 responses from college students and findings revealed anxiety and depression to be higher in the smartphone overuse group than in the normal use group [12]. In addition, Park et al. [14] studied depression using the Beck Depression Inventory (BDI) in "heavy" smartphone users, which they defined as those who spent 5.4 hours a day on their smartphone. Their sample consisted of 20 healthy student participants and the investigators reported that smartphone use could cause negative effects on a person's psychological status, such as depression ($p = 0.006$) [14].

Although it is clear that the neck is the area commonly reported to have the highest pain among smartphone users [9, 10], investigation on the ergonomic factors leading to neck pain among smartphone users remains limited [5]. Neck pain is known to be a multi factorial disorder, with head and spinal posture being one of the most important factors. Previous studies concluded that prolonged neck flexion is highly associated with neck pain both among the general population [15] and among office workers who use computers [16–18]. Similarly, the neck flexion posture is commonly adopted while smartphone users view the visual display terminals of smartphones for extended periods. Kang et al. [19] reported that this posture causes musculoskeletal problems [19]; however, the association between neck flexion during smartphone use and neck disability has not been scientifically confirmed to date. Furthermore, there are possible influential factors, which are reported to be associated with neck disorders in the general population, however, these have not been studied among smartphone users who smoke or suffer from stress.

The purpose of the current study was to investigate MSDs in smartphone users in Thailand in order to confirm high prevalence of neck pain. The study also aimed to determine all possible factors associated with neck disorders among smartphone users. The hypothesis was that ergonomic factors like neck postures are associated with neck disorders among smartphone users. The findings of this study can produce important information for exploring associations between intensive smartphone use and the occurrence of neck disorders. Additionally, the information may be used to underpin prevention and health promotion initiatives to address the risk of neck disorders associated with smartphone use.

2. Methods

2.1. Study design

This study used a cross-sectional design. A paper-based questionnaire was used to collect self-reported measures of smartphone use and self-reported musculoskeletal disorders in neck, shoulder, elbow, wrist and hand, upper back, lower back, hip and thigh, knee and ankle and foot. Data collection took place between August 1st, 2015 to January 30th, 2016. Prior to launching the study, human ethics approval was sought from the Khon Kean University. Informed consent was obtained from the subjects prior to completion of the self-administered questionnaire.

2.2. Participants

The sample of participants comprised 799 undergraduate students at Khon Kaen University, Thailand. The participants were recruited to the study by multistage random sampling. First, cluster sampling was used to randomly select 17 faculties in the Khon Kaen University, and then simple random sampling was used to select 47 students in each faculty. The exclusion criteria were: (1) graduate students, (2) unwilling participants and (3) obvious pre-existing musculoskeletal disorders which can be observed, such as joint deformity. Subjects without the exclusion criteria listed above were then asked to complete a questionnaire.

2.3. Questionnaire

The self-administered questionnaires were directly given to participants (face to face) in class. The questionnaire consisted of five sections which were: (1) demographic data (e.g. questions regarding sex, age, weight, height and other habits effecting health like smoking and exercise), (2) smartphone use data (e.g. questions regarding smartphone dimensions, data entry method, usage time and posture during use), (3) use of other devices data (e.g. questions regarding other devices usage type and usage time of other devices), (4) the Suanprung Stress Test-20 (e.g. questions regarding feelings of anxiety, dissatisfaction and confusion), and (5) the Thai language version of the Standardized Nordic Questionnaire (e.g. questions regarding aches, pains and discomfort in the neck within the last 12 months and the most frequent neck posture during smartphone use). The reliability and validity of the latter questionnaire was established in a pilot study (accepted as a high validity tool; validity (Index Of Consistency: IOC) = 0.6–1 and accepted as a moderate reliability tool; reliability (Cronbach Alpha) = 0.71) [20].

The Suanprung stress test-20 (SPST-20) is used to assess the level of stress. Concurrent validity in the Thai population standardizes with electromyography (EMG) more than 0.27 (significant with 95% CI). Cronbach's Alpha Reliability Coefficient of this test from a previous study is more than 0.7 with correlation to EMG significantly. This test is appropriate for students and adults. It is used to evaluate stress and interprets stress scores as follows: a score of 0 to 23 is defined as mild stress; a score of 24 to 41 is defined as moderate stress; a score of 42 to 61 is defined as high stress; and a score of 62 or more is defined as severe stress. The author further organizes this stress score into two categories. The first category indicates mild to moderate stress and the second category indicates high to severe stress [21].

A translated Thai language version of The Standardized Nordic Questionnaire (SNQ) is used to assess the prevalence of body part musculoskeletal discomfort within the last 7 days, last 12 months and to assess any trouble preventing normal work within the last 12 months. The SNQ is used to survey MSDs in the neck, shoulder, elbow, wrist and hand, upper back, lower back, hip and thigh, knee, ankle and foot. All answers are on a dichotomous scale (yes or no).

Saetan et al in 2007 translated a Thai language version of the SNQ. Both its content validity and linguistic suitability were tested by 5 experts and 30 samples were used to test the inter rater reliability between rater. The reliability of the Thai language version was reported to be Kappa 0.66–1 [22]. Moreover, we gave posture choices in each of the body parts (neck, shoulder, elbow, wrist and hand, upper back, lower back, hip and thigh, knee, ankle and foot) followed by the Thai language version of the Standardized Nordic Questionnaire for smartphone users, asking them to describe their posture during smartphone use by indicating postures assumed by various body parts from a menu.

2.4. Data analysis

Descriptive statistics were used to analyze characteristics of participants and musculoskeletal disorder variables. Continuous variables were analyzed by mean and Standard Deviation (SD). The continuous variables included age, weight, height, study hours per day, years using smartphone, average hours using smartphone at a time and per day, years using other electronic devices, average time using other devices at a time and per day. Categorical variables were considered in terms of frequency and percentage. Categorical variables included: gender, Body Mass Index (BMI), hand dominance, smoking behavior, alcohol drinking behavior, exercise behavior, underlying disease, underlying musculoskeletal disorders, accident history, characteristics of smartphones used (namely model, brand etc.), stress, and musculoskeletal disorders. Simple logistic regression analysis was used to include each independent variable into a multiple logistic regression model; variables with a *p*-value less than 0.2 were included in the multiple logistic regression model. Multiple logistic regression analysis was performed using a stepwise regression process; variables with *p*-values of less than 0.05 were considered to be statistically significant. Data were analyzed using the STATA program version 10 (STATA, College Station, TX, USA).

3. Results

3.1. Demographic information of the smartphone users who had musculoskeletal disorder

All 799 students completed the questionnaire (i.e. 100% response rate). Responses from 643 of the 799 smartphone users met the inclusion criteria and these responses were analyzed. The general characteristics of the smartphone users who had musculoskeletal disorders are presented in Table 1. There were 184 male (28.62%) and 459 female (71.38%) smartphone users who reported musculoskeletal disorders in this study. The majority of participants reported: a BMI value in the normal range (89.74%), right hand dominance (87.25%), no history of smoking (93.78%) or drinking alcohol (62.67%), currently engaged in exercise (59.72%), no underlying disease (81.80%), no underlying musculoskeletal disease (98.29%) and no history of general accident (88.34%) whereas some of them got only general accidents like contusion wound in upper and lower extremities (11.66%). The average age of participants was 18.82 ± 0.79 years, weight was 55.95 ± 10.83 kilograms, height was 163.38 ± 7.67 centimeters and study hours per day was 6.03 ± 1.49. Almost half of the smartphone users who reported musculoskeletal disorders also reported high stress (43.08%).

3.2. Characteristics of smartphones used by respondents who reported musculoskeletal disorders (n = 643)

The characteristics of the smartphones used by participants who reported musculoskeletal disorders are presented in Table 2. The majority of the smartphone users who had musculoskeletal disorders used smartphone brand A (52.26%), especially model A (12.91%) with touch screen type (95.65%). The dimensions of smartphones used had an average length of 133.24 ± 12.50 mm, average width of 66.99 ± 7.32 mm, average thickness of 8.28 ± 1.28 mm, average weight of 134.30 ± 22.43 gram, and average screen size of 4.46 ± 0.69 inches. Respondents reported they had used smartphones for 4.60 ± 2.66 years, used their smartphone 1.04 ± 1.47 hours per time and used it 5.03 ± 3.37 hours per day. Additionally, more than half the participants used smartphones in the evening (79.63%) and they had rest time during use (93.62%), both hands were used to hold the smartphone (48.06%), and participants reported they entered data using both thumbs (55.37%) in a sitting posture (69.52%) for social network purpose such as Facebook and LINE applications (LINE application is a freeware application for instant communications on electronic devices such as smartphones, tablet computers, and personal computers and it is the most popular texting application in Thailand) (84.29%). In addition, participants also

Table 1
Demographic information of the smartphone users who had musculoskeletal disorders ($n = 643$)

Characteristics	*n* (%)	Mean ± SD	Min-Max
Sex			
Male	184 (28.62)		
Female	**459 (71.38)**		
Age (years)		18.82 ± 0.79	17.00–26.00
Weight (kg)		55.95 ± 10.83	38.00–110.00
Height (cm)		163.38 ± 7.67	145.00–186.00
Body Mass Index (kg/m^2)			
Normal	**577 (89.74)**		
Overweight (≥25 kg/m^2)	66 (10.26)		
Study hours per day (hours/day)		6.03 ± 1.49	1.00–12.00
Hand dominance			
Right	**561 (87.25)**		
Left	69 (10.73)		
Both	13 (2.02)		
Smoking behavior			
Current smoker	11 (1.71)		
Former smoker	29 (4.51)		
Never smoked	**603 (93.78)**		
Drinking behavior			
Current drinker	64 (9.95)		
Former drinker	176 (27.37)		
Never drank	**403 (62.67)**		
Exercise behavior			
Currently exercise	**384 (59.72)**		
Formerly exercise	171 (26.59)		
Never exercised	88 (13.69)		
Underlying disease			
Yes	117 (18.20)		
No	**526 (81.80)**		
Musculoskeletal underlying disease			
Yes	11 (1.71)		
No	**632 (98.29)**		
History of general accident			
Yes	75 (11.66)		
No	**568 (88.34)**		
Suanprung stress test level			
Mild stress	79 (12.29)		
Moderate stress	201 (31.26)		
High stress	**276 (42.92)**		
Severe stress	87 (13.53)		

reported using other devices (79.63%) especially laptops (76.62%) which they reported they had used for the previous 6.71 ± 3.89 years, used 1.94 ± 1.44 hours per time and used 3.55 ± 2.66 hours per day.

3.3. Postures assumed during smartphone use by those who reported musculoskeletal disorders

Smartphone users described their posture during smartphone use by indicating postures assumed by various body parts from a menu, The majority of smartphone users who reported musculoskeletal disorders adopted positions of: neck flexion (82.74%), shoulder protraction (56.61%), elbow flexion (65.16%), wrist and hand flexion during keying (22.40%), wrist and hand supination to support the device (21.62%), upper back flexion (67.50%), lower back flexion (43.23%), hip and thigh flexion (37.95%), knee flexion (67.81%) and ankle and foot neutral (61.59%) positions during smartphone use.

3.4. The prevalence of musculoskeletal disorders among smartphone users

The prevalence of musculoskeletal disorders was highest in the neck (32.50%), shoulder 26.91%, upper back 20.69%, wrist and hand 19.75%. Musculoskeletal disorders were less prevalent in the lower back

Table 2
Reported smartphone use data by users with musculoskeletal disorders ($n = 643$)

Characteristics	*n* (%)	Mean ± SD	Min-Max
Brand			
A	**336 (52.26)**		
B	203 (31.57)		
C	20 (3.11)		
Others	84 (13.06)		
Model			
A	**83 (12.91)**		
B	81 (12.60)		
C	65 (10.11)		
Others	414 (64.38)		
Type			
Touch screen	**615 (95.65)**		
Keypad with a touch screen	28 (4.35)		
Length (mm)		133.24 ± 12.50	103.70–166.90
Width (mm)		66.99 ± 7.32	47.00–93.00
Thickness (mm)		8.28 ± 1.28	1.35–15.20
Weight (g)		134.30 ± 22.43	75.00–326.00
Screen size (inch)		4.46 ± 0.69	2.20–6.00
The start time until the current time (years)		4.60 ± 2.66	0.02–15.00
Usage time per time (hours)		1.04 ± 1.47	0.03–20.00
Usage time per day (hours)		5.03 ± 3.37	0.08–24.00
Time period			
Morning	11 (1.71)		
Noon	13 (2.02)		
Afternoon	28 (4.35)		
Evening	**512 (79.63)**		
Others (such as before bed)	79 (12.29)		
Rest time			
Yes	**602 (93.62)**		
No	41 (6.38)		
Main hand			
Only right side	303 (47.12)		
Only left side	31 (4.82)		
Both sides	**309 (48.06)**		
Data entry method			
Held by both hands while entering data using both thumbs	**356 (55.37)**		
Held by both hands while entering data using right thumb	113 (17.57)		
Held by both hands while entering data using left thumb	11 (1.71)		
Held by right hand while entering data using right thumb	136 (21.15)		
Others	27 (4.20)		
Posture in use			
Sitting	**447 (69.52)**		
Standing	9 (1.40)		
Walking	3 (0.47)		
Lying	182 (28.30)		
Others	2 (0.31)		
Purpose of use			
Social network (such as Facebook, Line application)	**542 (84.29)**		
News	26 (4.04)		
Data searching	16 (2.49)		
Entertainment (such as TV, Clip, Movies and radio)	51 (7.93)		
Others (such as game playing)	8 (1.24)		

(*Continued*)

Table 2
(*Continued*)

Characteristics	*n* (%)	Mean ± SD	Min-Max
Other devices using			
Yes	**512 (79.63)**		
No	131 (20.37)		
Other deices type			
Mouse	1 (0.20)		
Laptop	**390 (76.62)**		
Personal computer	54 (10.61)		
Tablet	64 (12.57)		
The start time until the current time of other devices (years)		6.71 ± 3.89	0.10–18.00
Usage time per time of other devices (hours)		1.94 ± 1.44	0.17–10.00
Usage time per day of other devices (hours)		3.55 ± 2.66	0.03–20.00

17.26%, the hip and thigh 9.80%, the knee 7.31%, the ankle and foot 6.69% and the elbow 4.97%.

3.5. Relationship between neck disorders and associated factors

The relationship between neck disorders and associated factors is presented in Table 3. This study found that personal factors like smoking (OR 8.99, 95% CI 1.88–42.87) and ergonomic factors like neck flexion posture (OR 2.44, 95% CI 1.21–4.90) were factors associated with the occurrence of neck musculoskeletal disorders in smartphone users.

4. Discussion

The purpose of this study was to determine associations between neck flexion postures and neck disorders among smartphone users. The current study found that smoking and neck flexion posture were associated with the occurrence of neck musculoskeletal disorders in the smartphone users.

Smoking is an important individual risk factor for neck musculoskeletal disorders [23]. It is clear that cigarette smoking has deleterious effects on the musculoskeletal system [24]. Two recent systematic reviews published by Hogg-Johnson et al. [25] and Côté et al. [26] evaluated the determinants of neck pain. The former found evidence that exposure to passive smoking in adolescents increased the risk of neck pain. The latter review summarized that smoking increased the risk of neck pain among the working population [25, 26]. The current study is the first to show smoking is a factor associated with neck disorders in smartphone users. The odds ratio for this was high because there were 11 participants who identified themselves as current smokers and 9 of them had musculoskeletal disorders in the sample of 643 participants. The Khon Kaen University is a non-smoking campus which may account for the low number of smokers in the current study. In the future, it would be useful to study a specific 'smoker only' group to clearly confirm this finding. In linking smoking with neck pain, clinical and experimental studies have shown that cigarette smoking induced skeletal muscle damage due to impaired muscle metabolism, increased inflammation and oxidative stress [27]. These could be affected by the occurrence of neck pain in university student smartphone users.

Neck flexion is the most common posture smartphone users adopt when looking at their smartphone visual display terminals for long duration of time and such postures may cause musculoskeletal problems [19] especially in the neck region [5]. Kim et al. [28] studied the influence of the duration of smartphone use on cervical and lumbar spine flexion angles and reposition error in the cervical spine in 18 healthy smartphone users. They measured the kinematics of the upper and lower cervical and lumbar spine flexion angles and the reposition error of the upper and lower cervical spine after 3 seconds (s) and 300 s (five minutes) of smartphone use in sitting. They reported that the flexion angles of the lower cervical and lumbar spine and the reposition error in the upper and lower cervical spine were significantly increased after 300 s of smartphone use ($p < 0.05$). However, the flexion angle of the upper cervical spine was not significantly different between the 3 s and 300 s smartphone of use ($p > 0.05$). These findings suggest that prolonged

Table 3
The relationship between neck disorders and associated factors

Characteristics	Neck	
	ORcrude (95% CI)	ORadjust (95% CI)
Sex		
Male	1.00	
Female	1.07 (0.74–1.54)	–
Age (years)		
$<18.82 \pm 0.79$	1.00	
$\geq 18.82 \pm 0.79$	0.76 (0.54–1.08)*	–
Weight (kg)		
$<55.95 \pm 10.83$	1.00	
$\geq 55.95 \pm 10.83$	0.85 (0.61–1.19)	–
Height (cm)		
$<163.38 \pm 7.67$	1.00	
$\geq 163.38 \pm 7.67$	0.90 (0.65–1.27)	–
Body Mass Index (kg/m^2)		
Normal	1.00	
Overweight ($\geq$25 kg/m^2)	0.62 (0.35–1.11)*	0.57 (0.31–1.05)
Study hours per day (hours/day)		
<6	1.00	
≥6	1.26 (0.86–1.86)*	–
Hand dominance		
Other	1.00	
Right	1.11 (0.68–1.83)	–
Smoking behavior		
No	1.00	
Yes	9.72 (2.34)*	8.99 (1.88–42.87)#)
Drinking behavior		
No	1.00	
Yes	1.28 (0.75–2.17)	–
Exercise behavior		
Yes	1.00	–
No	1.25 (0.90–1.76)*	
Underlying disease		
No	1.00	
Yes	1.20 (0.79–1.83)	–
Musculoskeletal underlying disease		
No	1.00	
Yes	1.74 (0.56–5.46)	–
History of general accident		
No	1.00	
Yes	1.69 (1.00–2.87)*	1.54 (0.89–2.68)
Suanprung stress test level		
Mild-moderate stress	1.00	
High-severe stress	1.26 (0.90–1.76)*	–
Brand		
Other brands	1.00	
Brand A	0.99 (0.69–1.34)	–
Model		
Other models	1.00	
Model A	1.09 (0.66–1.77)	–
Type		
Keypad	1.00	
Touch screen	1.01 (0.46–2.24)	–
Length (mm)		
$<133.24 \pm 12.50$	1.00	
$\geq 133.24 \pm 12.50$	0.90 (0.64–1.25)	–
Width (mm)		
$<66.99 \pm 7.32$	1.00	
$\geq 66.99 \pm 7.32$	0.90 (0.64–1.26)	0.57 (0.31–1.05)

(*Continued*)

Table 3
(*Continued*)

Characteristics	Neck	
	ORcrude (95% CI)	ORadjust (95% CI)
Thickness (mm)		
<8.28 ± 1.28	1.00	
≥8.28 ± 1.28	1.21 (0.87–1.69)	–
Weight (g)		
<134.30 ± 22.43	1.00	
≥134.30 ± 22.43	1.01 (0.72–1.40)	–
Screen size (inch)		
<5	1.00	
≥5	0.93 (0.66–1.34)	8.99 (1.88–42.87)
The start time until the current time (years)		
<4.60 ± 2.66	1.00	
≥4.60 ± 2.66	1.08 (0.78–1.51)	–
Usage time per time (hours)		
<1	1.00	
≥1	0.87 (0.62–1.21)	–
Usage time per day (hours)		
<6	1.00	
≥6	1.14 (0.82–1.60)	–
Time period		
Other time periods	1.00	
Evening	0.67 (0.45–1.00)*	–
Rest time		
Yes	1.00	
No	0.65 (0.32–1.34)	–
Main hand		
Both sides	1.00	
Only one side	0.98 (0.71–1.36)	–
Data entry method		
Hold both sides	1.00	
Hold only one side	0.83 (0.56–1.22)	–
Posture in use		
Other postures	1.00	
Sitting	0.95 (0.67–1.37)	–
Purpose of use		
Other purposes	1.00	
Social network	1.39 (0.86–2.22)*	–
Other devices using		
No	1.00	
Yes	1.28 (0.84–1.96)*	–
Other devices type		
Other devices	1.00	
Laptop	1.17 (0.76–1.81)	–
The start time until to current time of other devices (year)		
<6.71 ± 3.89	1.00	
≥6.71 ± 3.89	0.90 (0.65–1.26)	–
Using time per time of other devices (hour)		
<1.94 ± 1.44	1.00	
≥1.94 ± 1.44	1.00 (0.71–1.40)	–
Using time per day of other devices (hour)		
<3.55 ± 2.66	1.00	
≥3.55 ± 2.66	1.10 (0.79–1.52)	–
Neck posture		
Neutral	1.00	
Flexion	1.72 (0.95–3.12)*	2.44 (1.21–4.90)#)

Note: *Significant at the P-value <0.2 level was including into the model of logistic regression, #Significant at the P-value <0.05 level.

use of smartphones can induce changes in cervical and lumbar spine posture and proprioception in the cervical spine [28].

Park et al. [14] evaluated two groups of 10 healthy Korean student smartphone users based on the length of time spent on their smartphones. The researchers categorized the two groups into 'heavy' smartphone, defined as those who spent 5.4 hours a day on their smartphone, compared to a 'control' group who spent an average of 4.1 hours a day on their smartphone. The researchers measured participant craniovertebral angle, head position angle, pain threshold of the sternocleidomastoid and upper trapezius muscles, and presence of depression. They found significant differences between the groups in the pain threshold of the sternocleidomastoid and upper trapezius muscles, head position angle, and depression ($p < 0.05$), but not in the craniovertebral angle. Based on the results, their study showed that 'heavy' smartphone use may produce considerable stresses on the cervical spine, thus changing the cervical curve and pain threshold of the muscles around the neck. Smartphones could also cause negative effects on a person's psychological status, such as depression [14].

Lee et al. [5] assessed posture during smartphone use in 18 participants in a laboratory setting. Their measurements included the amount and range of head flexion of smartphone users, head forward flexion angle while they were conducing three common smartphone tasks (text messaging, web browsing, video watching) while sitting and standing. They found that participants maintained head flexion of 33°–45° from vertical when using the smartphone. The head flexion angle was significantly larger ($p < 0.05$) for texting than for the other tasks, and significantly larger while sitting than while standing. Their study results suggest that texting, which is one of the most frequently used app categories of smartphone, could be a main contributing factor to the occurrence of neck pain of 'heavy' smartphone users [5].

Ning et al. [29] also evaluated the neck extensor muscle activities and the kinematics of the cervical spine during the operation of a touchscreen tablet and a smartphone in 14 participants. Participants of this study maintained significantly increased neck flexion angle when operating a smartphone (44.7°), with the mobile devices set on a table (46.4°), and while performing a typing task (45.6°) [23]. This study had apparently shown that during smartphone use, smartphone users also maintained their head flexion in various angles conforming to Lee et al. [13]. They also demonstrated that the magnitude of neck flexion was affected by the size of the screen, device location and the tasks performed [29]. Task influenced cervical spine posture with the highest cervical flexion occurring while completing a simulated data entry task [30]. Awkward posture like neck flexion refers to positions of the body that deviate significantly from the neutral position while tasks are being performed and it is the primary ergonomic risk factor for developing musculoskeletal discomfort [31]. In addition, elevated neck muscle activities were observed while holding mobile devices in hand (vs. putting them on a table) and elevated neck muscle activities also were observed while performing typing and gaming tasks (vs. reading task) [29]. These occurrences could be a main associated factor to the occurrence of neck pain.

Hansraj [32] assessed stresses on the cervical spine caused by posture and position of the head and reported that the weight taken by the spine dramatically increases when flexing the head forward at varying degrees. Loss of the natural curve of the cervical spine leads to incrementally increased stresses about the cervical spine [32].

In summary, all of the reasons above support the association we found in our study; that is, neck flexion postures in smartphone users are associated with the occurrence musculoskeletal disorders of the neck.

Our study is the first to examine stress in relation to neck disorders in smartphone users, and we found no association between stress and smartphone use. Previous studies of psychosocial factors revealed anxiety and depression to be higher in smartphone users [12, 14] but we are not able to comment on these individual psychosocial factors. Rather, the Suanprung Stress Test – 20 that we used in our study provides a measure of stress because this test is appropriate for Thai student and adulthood [33].

Our study found the average size of smartphone liquid crystal displays was 4.46 ± 0.69 inches which is smaller than the average size of smartphones reported in previous studies [9]. It is possible that smaller screen size may relate to different neck postures to improve vision, because smaller screens will cause a deeper bending of the neck to reduce the distance between the eyes and the screen, as well as increase the clarity of vision. The deeper neck bending could be due to elevated neck muscle activities, and this will affect neck pain respectively. Mobile devices with larger screen sizes are preferable from the MSD prevention perspective. However, larger screen sizes may also increase the weight of the device, which could introduce fatigue to arm and shoulder muscles when holding these devices for prolonged periods of time [29]. And this remains to be tested in future studies. It is interesting to note that most participants in this study held their smartphones with both hands, which is a good ergonomic for smartphone users. Holding a smartphone with one hand presents a higher risk for a musculoskeletal lesion, as compared with holding it with both hands [34].

Regarding of the implication of this study, the findings reveal an important information of an association between intensive smartphone use and the occurrence of neck disorders. Additionally, the information may be used to develop prevention measure and health promotion initiatives that aim to decrease neck flexion and smoking to address the risk of neck disorders associated with smartphone users.

The current study has some limitations. A general limitation of cross-sectional studies is that they do not show cause and effect [35]; however, this method was useful as a starting point to gauge smartphone use and associated symptoms in the university student population. Our study also did not examine some characteristics of daily smartphone use reported in other studies (e.g. number of text messages and neck postures). Furthermore, as our sample consisted of only young people we cannot compare differences between younger and older age groups as previous studies have. Additionally, it should be noted that a self-administered questionnaire increases the risk of response bias [9]. In future studies we suggest participants should be included from beyond the university student sector, and a cohort with more smoking smartphone users should be studied to confirm our finding of smoking as an associated factor.

5. Conclusion

Individual factor of smoking and ergonomic factor of the neck flexion posture were both associated with the occurrence of neck musculoskeletal disorders in smartphone users in the present study. To the best of our knowledge, this is the first study which has demonstrated that neck disorders in smartphone users are associated with neck flexion postures and smoking. The current data suggests that neck disorders in smartphone users can be reduced through measures that aim to decrease neck flexion and smoking.

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Conflict of interest

None to report.

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